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## ABSTRACT

The first of four main sections of the electronics occupations curriculum guide is an introduction which describes the design and use of the guide and which provides five pages of suggested curriculum resources. Section two contains job descriptions for 12 electronics occupations. For each occupation the guide explains industry's expectations of the person performing that job and outlines the basic skills that must be learned to gain an entry-level job. Section three contains 43 educational blocks of specific skills or portions of a skill that need to be learned, each of which provides references, a general objective, and a topical outline specifying skill objectives and recommended time. Each job description in section two makes specific reference to the appropriate educational blocks in section three, thus providing a cross reference between the two sections. Part four is an appendix which illustrates such things as electrical charts, forms, abbreviations, tables, symbols, and equipment, and provides a glossary, a list of references, and criteria for placing handicapped students. (JR)

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# Electronics Occupations Curriculum Guide

## July 1975

ILLINOIS OFFICE OF EDUCATION

Division of Vocational and Technical Education

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# ELECTRONICS OCCUPATIONS

## CURRICULUM GUIDE

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The project staff would like to take this opportunity to thank the following Steering Committee members and the industries and educational institutions that they represent for their continued support of the project. Their input was greatly appreciated, and was vital to the success of our efforts to product effective industry-based curriculum guides for high school electricity-electronics instructors.

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American Line Builders Apprentice Training, Champaign, Il.  
Illinois Power Company, Champaign, Il.

Following are some comments made by Steering Committee members:

I. From Richard Burritt, Training Supervisor, Caterpillar Tractor Company

*The electricity-electronics curriculum guides are valuable tools for course development at the secondary school level. Because of job diversification within the electricity-electronics field, a specific job objective can be achieved only through properly directed training. These guides will give the proper direction to this training.*

II. From David Timmersman, Jr., Engineering Supervisor, Module Engineering, Micro Switch, Division of Honeywell.

*Education has a wonderful way of flattering the world of industry while calling its bluff. Being asked to serve on TERC's Electricity-Electronics Curriculum Guide Committee was a threat, a challenge and a compliment all in one. Therefore, although I accepted the invitation to serve with great reservation, I completed the assignment with fascination.*

*In my opinion, the interface generated by TERC in our several meetings was singularly productive. I have no hesitation in concluding that the curriculum guide established by (the project staff) meet the requirements of industry. I am sure that this guide will be a constructive vehicle for the dedicated teachers who will be conducting the high school electricity-electronics programs throughout the state. Keeping the course interesting will be the key!*

*It was an honor to have been asked to share my experiences with you, my fellow industrial representatives and the selected teachers from the Illinois public schools.*

III. From M. A. Wittevrongel, Coordinator-Consultant and Electricity/Electronics Consultant, Granite City Steel

*Please accept my thanks for the privilege of serving on your Electricity-Electronics Steering Committee. It was a most rewarding experience. I was impressed by the support this undertaking generated in the industrial and service community. The potential employer's intense interest in helping to establish basic instruction in the public schools was most heart-warming. Their candid analysis of the instructor's problems makes one realize that school's efforts are not unappreciated, and that industry is standing just outside the door, waiting for an invitation to come in and help.*

*From the committee interest exhibited, I believe that this project was long overdue and will prove to be a real asset to the vocational electricity-electronics programs in Illinois.*

IV. From E. F. Olver, Professor, University of Illinois.

*In my estimate no subject matter is more important today in our technical society than the Electricity-Electronics materials developed by our steering committee for high school classes. It is a most neglected area. The staff of TERC has done a fine job. I have been very pleased to participate in this vital program.*

V. From Robert A. Billing, Service Area Engineer, Illinois Power Company.

*I want to thank you for inviting me to be a member of your Electricity-Electronics Steering Committee. I am indeed appreciative of the fact that I could contribute my small part to the large task that you undertook.*

*I believe that the Electricity/Electronics Curriculum Guide will be a great aid to the Vocational Instructor. It will help the Instructor to formulate his course of study and direct his efforts to the occupational units most needed in his immediate area.*

*It has been a pleasure working with (The project staff). If I can be of any future service to you, please feel free to call me.*

## INTRODUCTION

Given our current economic situation, it is more important than ever that a teacher in vocational electricity-electronics have the tools to prepare his students to go directly into industry at the end of their courses. The instructor, therefore, has a responsibility to continually keep himself assessed of the state of the art in the field of electricity and electronics. Up to the present, however, it has been difficult for an instructor to find the materials and curriculum that would help him achieve that goal. This lack has been due primarily to a lack of communication between industry and the instructor and the curriculum that he has been using. Robert L. Stark and Sharon Chace of Technical Education Research Center, Inc. (TERC), with David A. Peterson and Robert L. Laursen from Parkland College, have developed a unique set of curriculum guides which can fill this communication gap. The Electricity-Electronics Curriculum Guide Project was funded under a contract grant from the State of Illinois Board of Vocational Education and Rehabilitation, Division of Vocational and Technical Education. The guides are divided into two main portions: a job skills portion which lists and describes entry-level jobs; and an educational block portion which outlines educational experiences needed to learn the job skills. In addition to the two main portions, the guides contain descriptive introductory material, a cross-reference system which indexes the two main portions, and several appendixes of supporting material.

## PROJECT OPERATION

The curriculum project was initiated on September 1, 1974, when the Division of Vocational and Technical Education of the State of Illinois approved a proposal submitted by Technical Education Research Centers entitled "*A Proposal to Design and Publish Industry-Based Curriculum Guides in Electricity-Electronics Occupations*". The purpose of the project was to design and publish two separate industry-based curriculum guides to help high school vocational instructors develop, teach and evaluate their electricity and electronics programs. Emphasis was placed on the development of curricula that would either enable the student upon leaving high school to be employed in an entry-level electricity or electronics job, or that would adequately prepare him for the post secondary training programs which some electricity-electronics job occupations require.

The project was implemented in four phases. The *first phase* was concerned with identifying and defining entry-level electricity and electronics occupations in Illinois; the *second phase* involved the compilation and evaluation of a skills list for each job occupation established in phase one; the *third phase* was concerned with the correlation of the occupational information with appropriate curriculum activities; and the *fourth phase* was concerned with the writing and publication of the two guides.

### INDUSTRY-BASED STEERING COMMITTEE

Each of these phases was accomplished through a series of continuing and interrelated project activities. One of the most important of these activities was the organization of an industry-based Steering Committee. The purpose of the committee was to ensure that persons familiar with industry and industrial training programs were available to provide input to the development of the guides. The Steering Committee and project staff met regularly throughout the progress of the project. As a unit, the committee functioned to provide a sounding board for staff research and development activities. Individually, steering committee members assisted by contributing curriculum materials, by arranging for on-site visitations to industrial training centers and in many other ways. Using the valuable insight of steering committee members selected from industries and public schools who were familiar with industry-based training, it has been possible to compile curriculum guides which coordinate the present demands of industry with the practical problems of teaching in the classroom.

## *INDUSTRY OCCUPATIONAL INFORMATION*

In addition to the input provided by Steering Committee representatives, occupational information was solicited from two hundred industries listed in the Illinois Manufacturer's Directory. A letter was mailed to the personnel director of the industries requesting job title and description information for entry-level electricity and electronics positions in the firm. Follow-up letters were sent to those industries that did not answer the initial communication. A record was kept of the responses received from the various industries contacted and relevant information and materials were incorporated into the project.

## *OCCUPATIONAL LITERATURE AND CURRICULUM MATERIALS*

At the same time that job title and description data was being compiled the staff was conducting a literature and curriculum materials search. The purpose of this search was to supplement input obtained directly from industries and also to provide data on training programs and curriculum materials being utilized across the country in schools and in in-house training programs. Information concerning electricity and electronics job titles, descriptions and required skills was obtained from steering committee members, participating industries and resource references such as the Occupational Outlook Handbook, the Job Description and Classification Manual, the Concise Handbook of Occupations, and the Dictionary of Occupational Titles.

## DESIGN OF THE CURRICULUM GUIDES

Through the planning stages of the guides, it became evident that basing the curricula on industry and their expectations of performance was a valuable way of helping teachers and their students. As different industries shared descriptions of their entry-level jobs for people in electricity and electronics related fields it was clearly seen that if instructors could be made aware of these requirements and had a source book that could tell them in what relative order these requirements or skills might be taught, then students would be better prepared for entry-level jobs. This became the underlying reason for setting up the guides in two main portions.

A "*Job Skills*" portion explains the types of jobs available, tells the expectations of industry in the performance of that job, and then outlines the basic skills that must be learned to gain an entry-level job. The second portion of the book is set up into "*Educational Blocks*". Each block handles a specific skill or phase that needs to be learned and then gives references, a topical outline for teaching the skill, and suggested time allowances. The electricity-electronics curriculum guides have a unique *cross-referencing system* which ties the "*Job Skills*" portion containing information on jobs in industry to the "*Educational Block*" portion in a way that will allow each teacher to select and adapt his course material to the industrial and vocational needs of his area. This allows the teacher to look into local industry and their needs and assess what entry-level jobs he can prepare students for; and then go to the guides to pull out job skills and educational blocks that would fit his students' needs and interests. He can assure his students of precise industrial training for entry-level jobs because he has at his disposal all the information that he needs. It is expected, of course, that each instructor also brings his own "hands-on" experience and background to the course.

In utilizing the "*Educational Blocks*" the instructor should be aware of the fact that the references, outline, and time allowances are merely suggested and should be adjusted according to the needs of the course, the instructor, and the student. For instance, the references that are listed in the "*Educational Blocks*" are not suggested textbooks for student use, but rather are listed to be used by the instructor as an additional source of information. There will also be a different emphasis on various parts of the outline, which will be dependent

on the job or occupation for which training is being given. In using the recommended topical outline the instructor can pick and choose from the topics depending on the jobs or occupations chosen and the topics previously covered by the student. The instructor should also be aware of the fact that the recommended time allotments listed for each topics in the "*Educational Blocks*" is approximate and may vary from one course of study to the next. Different occupations often require different levels of skill competence for the same skill, and some of the skills are primarily cognitive while others are more manipulative in nature and may require more time for skill competency. Therefore, the instructor should carefully calculate the amount of time he believes he needs to spend on each topic in the outline.

The type of program, the job skills students are prepared for, and the depth that the material is covered will be determined and adjusted by the local needs, the needs of the students, and the background of the instructor. To adequately utilize the suggestions and recommendations listed in the guides each instructor would need to assume a great deal of responsibility in designing his own curriculum. The instructor would certainly need to think of how a new program based on the curriculum guides would fit into his school. For example, since this is a rather specialized career preparation course, is there a career orientation course in electricity-electronics that might serve as an introductory course which a student might take prior to the specific job skills material offered through the curriculum guides? Possibly the instructor might wish to use the curriculum guides to revitalize an existing program rather than initiate a new program. In many cases, the instructor will be working with a large group of students learning the same job skills, whereas in other cases the student may be working completely alone and separately with an individualized curriculum.

Whether this course is being taught in a high school or area vocational center would also affect the way the instructor wished to present it. If the course of study can only be pursued for five hours a week rather than ten or fifteen, the depth of the presentations and the level of skill preparation will be proportionately affected. All of these options would require a different type of orientation and preparation, but they could all utilize the basic material presented in the curriculum guides as a beginning outline for formulating a course of study.

Obviously, all occupations are not covered in the "*Job Skills*" portion of the guides, but we feel that the basic skills as outlined in the "*Educational Blocks*" and the procedure used to develop the guide will enable the instructor

to design a curriculum for any electricity-electronics course. The *Cross-Reference* (Page 3-1) shows that there is a cluster of skills applicable to all occupations; i.e., Safety, Basic Electrical Parameters, Component Identification, etc. This information can serve as a base for developing other curriculum. By utilizing the *Cross-Reference Chart* and input from a local Steering Committee or Advisory Committee, an instructor should be able to design a curriculum to fit any occupation desired.

### HOW TO USE THE CURRICULUM GUIDES

1. To develop an industry-based program, the instructor should first identify and select entry-level occupations that are available in his area. Advisory committees, the Chamber of Commerce, telephone directory yellow pages, and input from local businesses and industry personnel are some of the sources available to the instructor to help him identify and select local entry-level occupations.
2. After determining a list of entry-level occupations in the area, the instructor should match these selected occupations to the relevant occupational units given in the first portion of the guides. The occupational units identify the skills (*Special Skills Required*) that a student is likely to need to be hired into an entry-level position in a particular occupation (such as residential electrician).
3. From the specific skills listing, the instructor is referred to an appropriate educational block (the second portion of the guides). The educational blocks are subdivided into tasks that must be mastered in the classroom before the skill has been learned. Each task is accompanied by a *recommended topical outline* that identifies the material to be covered. The educational blocks also include a *sequence chart* to help the instructor determine the order in which topics are to be covered, a *recommended time section* that gives the instructor an estimate of the time required to cover the material, and *suggested procedures* to help the instructor with suggested ideas and training aids.

4. AN EXAMPLE: -You have determined from your local IBEW that there is a demand for residential electricians in your locale. Since many of the students in your electricity class plan to remain in the area, and are interested in the topic, you turn to the occupational unit portion of the Electricity Curriculum Guide where you locate the occupational unit entitled "Residential Electrician". This unit notes what kinds of skills the student will probably have to be adept at when he applies for a job as a residential electrician. One of the skills listed in the *Specific Skills Required* section refers to the need for the individual to have a grasp of standard safety practices and procedures and OSHA standards. A notation has been included by this particular skill that Educational Block I.10 will help you teach your students about safety. You turn to block I.10 which provides a list of tasks to be mastered (i.e., "know first aid procedures") accompanied by a *recommended topical outline*. You follow this sequence through each job skill listed under Residential Electrician, noting the suggested sequence of tasks to be covered, the time involved, and the suggested procedures as you go along.
5. It must be emphasized that the guide is meant to provide a set of guidelines, and the instructor should be continually ready to modify its contents to fit the materials and equipment available to him; the time available to him; and to fit his own interests and abilities.

## GENERAL INFORMATION

### *THE UTILIZATION OF SCHOOL AND COMMUNITY RESOURCES*

As talks with members from industry progressed in the planning of the curriculum guide, it became evident that industry is very concerned and interested in the preparation of youth for industrial jobs. Local industry can play a major role in helping to define the skills that a high school student will need to be hired into jobs in the community. The instructor should arrange to visit various local industries and become acquainted with their operations. The instructor might also arrange for industry to provide personnel such as foremen, supervisors, personnel managers, etc., to come and talk to students about individual phases of the work being learned. In addition, many industries and businesses would welcome the opportunity to provide input to the development of high school training programs by providing representatives to serve on advisory committees. Industries could arrange for tours of their plant, and provide pertinent pamphlets and audio visual materials, and might also supply equipment for high school programs and classes that are operating on a limited budget. Another source of inexpensive equipment, including surplus electric and electronic parts, is government surplus depots such as the ones located at St. Charles and Springfield, Illinois.

The instructor should strive to keep other members of the school vocational and academic staff informed of what he is trying to accomplish so that cooperative activities that reinforce the student's learning can be developed. For example, the counseling staff would certainly be an asset in areas such as work attitudes and in helping to place students into job situations. In addition, since many students will continue their education beyond the secondary level, there is need for high school instructors to open and maintain lines of communication with community colleges and universities to help in the mutual understanding of educational goals and to maintain a high school training program which will most benefit the student in future educational situations.

Thus, the instructor's close articulation with industry, with staff members in school, and with college and university are all valid and necessary activities which interact to establish and maintain a relevant program in electricity-electronics.

An individual's work attitudes often have as much to do with their finding and keeping a job as the type and extent of their training. In many jobs contact with the public is an integral part of the job and the impression that the individual portrays to the public influences their impression of the company or organization. Employers look for employees who will convey a favorable impression by their appearance, manner, and conversation, because the employee will be a representative of the company or organization.

The type of attitude the student has toward people, toward his school program, and toward his school is often indicative of the type of attitude he will have toward his job. Often an employer is not as interested in a student's grades as in his attendance, his punctuality, how he gets along with others, and what he participated in when he was attending school. Since these qualities are so important to the employer when a student applies for a job the instructor should place a great deal of emphasis on them in any education program. The student should know and be aware of the fact that a negative attitude can narrow his chances and cause him to be passed over not only when he is seeking a job, but when promotions are being considered. A positive attitude can aid the student in succeeding on the job, in his personal life and in the community. When an individual has a positive attitude he is motivated. An individual who has a positive attitude and who is motivated will likely develop positive attitudes about his job, his supervisor, his company, and the organization. This is the type of employee an employer wants to hire. The following list of statements concerning the type of qualities wanted from employees was formulated by employers at a recent workshop meeting and reflects their desire to hire employees with good work attitudes.

*I WANT AN EMPLOYEE*

- ... Who likes his job -- who knows his job.*
- ... Who is always on the job unless excused.*
- ... Who keeps himself physically fit.*
- ... Who gets a bang out of a job well done.*
- ... Who wants to do a day's work for a day's pay.*
- ... Who wants to get ahead -- who is cheerful, not sullen.*
- ... Who works safely -- with due consideration for himself and his fellow-worker.*

- ... Who tries to avoid waste and cuts cost.
- ... Who looks for a better way to do the job.
- ... Who tells the truth, who is sincere.
- ... Who keeps a spirit of teamwork.
- ... Who gripes little and looks forward.
- ... Who asks questions when he needs help.
- ... Who is willing to face his personal problems squarely.
- ... Who tries to put himself in my place now and then.
- ... Who feels that his job is a privilege -- not a right. I would give a worker like that my best. You would too!

## **SAFETY**

In a national survey, mentioned in the section on *Work Attitudes*, business administrators and personnel managers look for employees who work safely - with due consideration for themselves and their fellow-workers. This important aspect of work is covered in a unit in the guides (Safety, I.10) and provides the theoretical tools and background to safety practices in the world of work. However, safety is more than a theory or learning to use first aid; it is a habit to be absorbed and used in practice on a daily basis in the classroom.

While an instructor is constantly aware of keeping up with new innovations and ideas in the world of electricity-electronics, perhaps it is not so usual to keep up with new innovations in the area of electricity-electronics safety. An occasional look at manuals and special articles on safety such as "An Accident Prevention Program for School Shops and Laboratories" by the U. S. Department of Health, Education and Welfare, Office of Education can be of great help in upgrading this particular area.

It is of vital importance that a teacher develop a permanent safety consciousness in students through his own example - always doing things the safe way. As a teacher works with his students he should teach accident prevention with a positive approach by stressing the right way to perform an operation and giving shop demonstrations emphasizing the safe use of hazardous machinery and of specific hand tools. As part of the daily classroom routine, a teacher should strive to develop in each student a sense of responsibility for his own safety and that of others, helping him recognize potentially hazardous situations and what safety practices he should be using in his day-to-day activities.

An instructor should also be aware of his own personal responsibility for the routine housekeeping procedures required in his shop or lab. This not only ensures a suitable working environment for the students in class; but also demonstrates one of the important aspects of safety consciousness; working in clean, clutter-free surroundings. The teacher should be sure that all work areas are being cleaned, that storage is provided in a safe area, and that proper cleaning equipment and solvent materials are being used. A routine check of electrical equipment is a necessity. Periodically, an analysis of all hazards in the area involving machines, hand tools, and general environment should be made and steps should be taken to correct potential hazards before they develop into accident-causing situations.

One recent resource presently on the market that may prove helpful is entitled:

Occupational Safety and Health Standards for General Industry,  
(Commerce Clearinghouse, Inc.: 4025 W. Penterson St., Chicago,  
Illinois 60646), amended through June 3, 1974.

The following curriculum resources are included to assist the instructor in locating information and agencies to help in planning and implementing an industry oriented curriculum. The information provided is common to many industrial jobs and is also common to many of the educational blocks, so it is listed here rather than in each specific educational block.

### GOVERNMENT MATERIALS

Many instructors overlook government materials when they are looking for resources to use in planning their instructional programs. Possibly this may be due to the fact that government materials are not always easy to find nor are most instructors familiar with how to locate the materials even when they are available. Actually, an instructor can find many publications just by being familiar with a few government documents that are regularly issued and know how to use them.

One of the most useful government documents printed on a regular basis is the Monthly Catalog. It is issued monthly and is a requisite in any researching of government documents. The Monthly Catalog lists the majority of all Government Printing Office publications under the name of their issuing agency. Each monthly issue has an index which lists, by subject, all the publications for that month. To find a document the instructor looks under the subject heading for the relevant title where both the title and the index number are listed. The index lists the index number on the left-hand side of each page. Once this number is determined, the complete description can be located by finding the number in the main portion of the catalog. The index of the Monthly Catalog is accumulated each December and allows the instructor to search the entire year's publications in one index. The Monthly Catalog costs \$7.00 per year and may be ordered by writing the Superintendent of Documents, Government Printing Office, Washington, D. C. 20402.

A second source that is helpful is the pamphlet Selected United States Government Publications, catalog number GP3.17. It is a free pamphlet and is mailed on request. Other government publications that may prove of interest are the Occupational Outlook Handbook, the Job Description and Classification Manual and the Dictionary of Occupational Titles.

The Northwest Regional Education Laboratory, 500 Lindsay Building, 710 S.W. Second Avenue, Portland, Oregon 97204, issues the publication entitled Vocational Instructional Materials for Trade and Industrial Occupations Available from Federal Agencies. The ERIC Clearinghouse on Vocational and Technical Education, Ohio State University, 1900 Kenny Road, Columbus, Ohio 43210, also publishes two useful publications. These are Abstracts of Research and Related Materials in Vocational and Technical Education (ARM); and its companion publication Abstracts of Instructional Materials in Vocational and Technical Education (AIM).

#### *CURRICULUM GUIDES, COURSES OF STUDY, AND SPECIAL REFERENCES*

There are many materials available from schools, commercial sources, and other publication sources that are also very useful to the instructor. Many of these publications can be found in the reference Books in Print (BIP). A second reference that may prove even more valuable is the Subject Guide to Books in Print (SGBIP). Following is a listing of some references which may prove useful to the instructor in electronics:

Suggested Guidelines for Developing a High School Trade and Industrial Program in Industrial Electronics, Trade and Industrial Education Services, State Office Building, Columbus, Ohio 1968.

Task Inventory for the Electronic Technician Industry, State of Washington Coordinating Council for Occupational Education, Olympia, Washington, 1970.

Curriculum Guide for Vocational Electronics, Board of Education, City of Chicago, Illinois 1967.

Apprenticeship Schedules Covering Electrical and Electronic Trades, U.S. Department of Labor, Manpower Administration, 1970.

Electricity-Electronics Occupational Cluster Guide, Oregon Board of Education, Salem, Oregon, 1969.

General Electricity - Electronics Technology, Georgia Department of Education, Atlanta, Georgia, 1964.

Industrial Education Course Outline of Electronics, Occupational Long Beach Unified School District, Long Beach, California, 1967.

Electronic Technician in Industry, State of Washington, Coordinating Council for Occupational Education, P. O. Box 248, Olympia, Washington 98501.

### *EDUCATIONAL SERVICES OF MANUFACTURERS AND GOVERNMENT AGENCIES*

Many manufacturers and government agencies commonly send out or give away large quantities of educational materials. The Illinois Manufacturer's Directory is commonly used source for locating Illinois manufacturers. The Thomas Register is a listing of major U.S. manufacturers by product type as well as by name. These references plus the Encyclopedia of Associations will give the instructor enough information to prepare lists of manufacturers and organizations to write for industrial information. Some typical government agencies and manufacturers supplying educational materials are:

- (a) Education Program Branch  
NASA  
Kennedy Space Center  
Florida 32899
- (b) Education Programs  
NASA  
Manned Spacecraft Center  
Houston, Texas 77002
- (c) Hickock Teaching Systems, Inc.  
Woburn, Massachusetts 01801
- (d) Hampden Engineering Corporation  
East Longmeadow, Massachusetts 01028
- (e) Feedback Inc.  
Berkley Heights, New Jersey 07922
- (f) Digiac Corporation  
Smithtown, L.I., New York 11781
- (g) Fabritek  
Los Angelow, California 90023

### *INDEXES TO POPULAR AND TECHNICAL MAGAZINES*

There are several resources printed regularly to assist the instructor to locate material in magazines and periodicals. Probably the best known is the Reader's Guide to Periodical Literature, which lists author, title and subject together alphabetically. The Reader's Guide is issued monthly and is compiled on a yearly basis. Another resource similar to the Reader's Guide that would be of help to the instructor is Science and Technology Index.

Much helpful information can be obtained from trade journals, manufacturer's magazines, or other informational publications. Articles on new products, product ratings and indexes are quite helpful, and many product ads have data retrieval cards or addresses where product information can be obtained by writing the manufacturer. Some of these trade journals and magazines are listed below:

a. Trade Journals

Bell Laboratories Record, Bell Laboratories, 463 West Street,  
New York, New York 10014.

CB Magazine, Publishing Industries, Inc.

Electronic Component News, Chilton Company, Radnor, Pennsylvania

Electronic Industries, Chilton Publishing Company, 401 Walnut Street,  
Philadelphia, Pennsylvania, 19106.

Electronic Instrument Digest, Milton S. Kiver Publications, Inc.  
222 West Adams Street, Chicago, Illinois 60606.

Electronics Technician, Ojibway Building, Duluth, Minnesota 55802.

Electronic Servicing, Intertec Publishing Company, Kansas City,  
Missouri.

Electronic News, Fairchild Publications, New York, New York.

Electronics World, Ziff-Davis Publishing Company, 1 Park Avenue,  
New York, New York 10016.

Photofact Reporter, Howard W. Sams and Company, 4300 West 62 Street,  
Indianapolis, Indiana.

Radio-Electronics, Gernsback Publications, Inc., Ferry Street,  
Concord, New Hampshire, 03302.

b. House Journals

Bell Telephone Magazine, Public Relations Dept. AT & T, 195  
Broadway, New York, New York 10070.

Collins Signal Magazine, Collins Radio, Dallas, Texas.

(The) Demodulator, Lenkurt Electric Company, San Carlos, California 94070.

Digital Newsletter, Digital Equipment Corporation, Maynard,  
Massachusetts 01754.

DuPont Innovation, Circulation Department, DuPont Building,  
Wilmington, Delaware 19798.

Electrical Design News, Rogers Publishing Company, 3375 South  
Bannock, Englewood, Colorado, 80110.

Electronic Age, Radio Corporation of America, 30 Rockefeller Plaza,  
New York, New York 10020.

Electronic Technology, Lab-Volt Educational Systems, Division  
of Buck Engineering, Farmingdale, New Jersey 07727.

General Radio Experimenter, General Radio Company, 22 Baker Avenue  
West Concord, Massachusetts 01781.

Hewlett Packard Journal, Measurement News, Hewlett Packard Company,  
1501 Page Mill Road, Palo Alto, California 94304.

Instrumentation, Honeywell Industrial Division, 1100 Virginia  
Drive, Fort Washington, Pennsylvania 19034.

Microwave Journal, Horizon House-Microwave Inc., 610 Washington  
Street, Dedham, Massachusetts 02026.

Occupational Education Bulletin, American Association of Junior Colleges,  
One Dupont Circle, N.W., Washington, D. C. 20036.

RCA Plain Talk and Technical Tips, RCA, Indianapolis, Indiana.

Semiconductor Applications, General Electric Company, Distribution  
Services, 1 River Road, Schenectady, New York 12304.

Solid State Design, William Bazy, 610 Washington Street, Dedham,  
Massachusetts.

Technical Education News, McGraw Hill Publishing Company, 330 W.  
42nd Street, New York, New York 10036.

Tekscope, Tektronix, P. O. Box 500, Beaverton, Oregon 97005.

#### AUDIO-VISUAL MATERIALS

There are super 8mm film loops, 16mm films, video tapes, slides, film-strips, tapes, tapescripts, transparencies and charts available from many sources to supplement a large portion of the subject matter contained in most electricity-electronics programs. Many of these aids can be rented for a nominal fee, and some are available at no cost to the school. A list of these materials has been compiled, cataloged and published and is available for the instructor's use. The handbook/catalog lists materials by type and topic with a short review of each item including the order source and cost of each aid.

Compilation of the 224-page handbook was sponsored by the Electronics Industry Association (EIA) and edited by Dr. Irving W. Larson of Bemidji State College, Bemidji, Minnesota. The instructor can obtain a copy of the EIA Electronics Multimedia Handbook edited by Dr. Irving W. Larson through Howard W. Sams and Co., Inc. Indianapolis, Indiana.

#### *CONFERENCES, WORKSHOPS AND TRADE SHOWS*

Conferences, workshops and trade shows can help the instructor become acquainted with new products or training aids in addition to making important contacts with cooperating industries. There are three trade shows held in Chicago, Illinois each year; (a) Consumer Electronics, (b) National Electronic Packaging Conference, and (c) National Electronics Conference. Similar information can be obtained by belonging to technical organizations and attending their meetings, conferences and workshops. Following is a brief list of some of these organizations which are based in Illinois:

IAEEE (Illinois Association of Electricity and Electronics Educators)

IVA (Illinois Vocational Association)

IIEA (Illinois Industrial Education Association)

((AA (Illinois Industrial Arts Association)

#### *AMATEUR RADIO*

Ham Radio can provide motivation to the students. A new FCC Amateur License (not requiring code) is about to be established by the F.C.C.

JOB TITLE Electronics Assembler

DOT # 726.781-010

USOE # 17.15

ALTERNATE TITLES Assembler, Lead Assembler, Production Machine Operator,  
Production Test Operator, Wireman (Girl), Assembly Inspector

EMPLOYING INDUSTRIES Any electronics equipment industry

COMMENT: Job requires minimal knowledge of basic fundamentals but great deal of hands-on practical work.

JOB DESCRIPTION:

Assembles electronic equipment, solders components on circuit boards, assembles mechanical parts, prepares and laces wiring harnesses, loads and operates automatic component insertion machines, operates soldering machines, operates simple test equipment on production line, inspects assemblies for errors using diagrams or wiring samples.

This job requires a high degree of manual dexterity and good color vision.

CREDIT: George W. Henry, Hal Communications Corporation, Urbana, Illinois.

**SPECIFIC SKILLS REQUIRED:**

- |   |        |
|---|--------|
| 1. Work safely using proper safety equipment and following established safety practices, procedures, and <u>OSHA</u> Standards. | I.10   |
| 2. Properly handle delicate parts, equipment, and system components.  | 0.24   |
| 3. Read simple pictorial diagrams.  | I.11.b |
| 4. Identify electrical components by physical characteristics, color codes, symbols, etc.                                       | 0.16   |
| 5. Construct assemblies from pictorial diagram or sample unit.  | 0.70   |
| 6. Properly use common hand tools.  | 0.13.a |
| 7. Do perfect quality hand soldering.   | 0.50   |
| 8. Identify common machine screw sizes and types.   | 0.13.a |
| 9. Prepare and lace cables from wire list or simple diagrams.   | 0.70   |
| 10. Properly use automatic component insertion and soldering machines.  | 0.70   |
| 11. Use simple continuity testers and read common meters and dials.   | I.19.a |
| 12. Use production-line test jigs.  | 0.70   |

**RECOMMENDED SCHEDULE OF EDUCATIONAL BLOCKS:**

NUMBER	I10	016	024	I11b	I19a	013a	050	070			
PAGE	3-4	3-8	3-14	3-16	3-22	3-40	3-44	3-48			

ALTERNATE TITLES Instrument Field Serviceman, Instrument Man, Instrument Technician, Instrument Calibration and Repairman, Instrument and Control Mechanic, Instrument Technologist

EMPLOYING INDUSTRIES All Industries

JOB DESCRIPTION:

Tests, troubleshoots, analyzes and calibrates simple and complex electrical, electronic and mechanical instruments and/or systems using a variety of test equipment such as: Vacuum tube voltmeters, analyzers, oscilloscopes and special test instruments. Analyzes circuits and by evaluating information gained through use of test equipment, repairs, adjusts, replaces parts and services instrumentation systems.

Performs above duties independently or in conjunction with other(s) at local customer site or at repair shop location. May perform bench repair duties when not involved in field activities.

Has to be able to check and evaluate the indicated measurements, and therefore, has to know not only the fundamental theory underlying the operation of the more common measurements related to the process (i.e., the four basic measurements of pressure, temperature, level and flow), but in addition others which may include density, humidity, and many more, as called for by the particular process. The installation of the primary elements for these measurements involves manual labor. The transmission of the measurements to indicators, recorders, or controllers requires transmission lines for electricity, air, or liquids. These have to be installed and checked for grounds and open circuits in the case of electrical lines, and for leaks in the case of air and liquid lines. The calibration of the charts or scales so that they read correctly must be done. May be required to maintain control valves, the most common form of final control element.

He or she must be familiar with all classes of measuring instruments and their calibration, their maintenance, and the physical principles on which they operate. He must be familiar with the basic theory of automatic process control, as well as associated hardware, such as sensors, transducers, controllers and control valves. He must have basic knowledge of the different methods of signal transmission, pneumatic, hydraulic, as well as electrical. In order to be able to apply instrumentation and control to an individual process he must know how the process operates. This requires extensive chemical training and a knowledge of mechanical and electrical devices used in the process.

NEEDS: Mechanical, electronic and mathematical aptitude; thorough knowledge of the operation, repair and servicing of marketed instruments and accessories; knowledge of the use of test equipment; ability to analyze and determine corrective measures to be taken as a result of information gained from test equipment operation; and ingenuity to devise solutions to functional problems without specific direction. Ability to disassemble, assemble, troubleshoot and operate electrical and mechanical instruments.

CREDIT: A. E. Staley Manufacturing Company Job Description, Decatur, Illinois.

## SPECIFIC SKILLS REQUIRED:

1. Work safely, using proper safety equipment and following established safety practices, procedures and OSHA Standards
2. Properly handle delicate parts, equipment, and system components.
3. Locate, read and interpret technical data, schematics, specifications, service data, manufacturer's bulletins, and flow diagrams.
4. Identify electrical/electronic components by physical characteristics, color codes, symbols, etc.
5. Properly use common hand tools.
6. Properly use common test equipment:
  - a. VOM-VTVM
  - b. oscilloscope
  - c. tube tester
  - d. transistor checker
  - e. logic probes
  - f. capacitor checker
  - g. counters
  - h. test jigs and fixture
  - i. special test and calibration equipment
  - j. other precision measuring instruments
7. Read, calibrate, troubleshoot precision instrumentation temperature, level, flow, P.H., etc. quantities.
  - a. meters
  - b. chart recorders
  - c. pneumatic and electronic controls
  - d. recording gauges
  - e. automatic controllers
  - f. electromechanical systems
  - g. transducers and senders
  - h. pneumatic control valves
  - i. reducing valves
  - j. pressure regulators
  - k. temperature regulators
  - l. steam and air traps
  - m. flow meters
  - n. transmitters and receivers
  - o. drive motors
  - p. refrigeration units
  - q. gauge cocks
8. Install and connect instrumentation systems, including mechanical and electrical connections.
  - a. wiring systems
  - b. intercabling
  - c. copper tubing
  - d. plastic tubing
  - e. stainless tubing
  - f. pipes and plugs
  - g. receptacles
  - h. galvanometers
  - i. control panels
  - j. flow panels
9. Properly use cleaners and lubricants.
10. Secure replacement parts and/or equipment substitutions.
11. Remove and replace defective parts and components correctly without damage to other parts.
  - a. unsolder
  - b. solder

Both on hand-wired and printed circuits.
12. Isolate and replace faulty modules.

I.10

0.24

I.11.b

0.16

0.13.a, 0.13.c  
I.19.a, I.19.b  
0.19.a

0.31

0.31, I.31,  
I.64

I.25  
I.11.b  
0.50

I.20.a, I.20.b,  
0.20.a, 0.20.b

NOTE: This occupation requires O.J.T. on the particular instruments used in job, in addition to the following sequence.

## RECOMMENDED SEQUENCE OF EDUCATIONAL BLOCKS:

NUMBER	I10	014a	016	015	024	I11b	017	I19a	I19b	I20a	I20b	014b
PAGE	3-4	3-6	3-8	3-12	3-14	3-16	3-20	3-22	3-24	3-26	3-28	3-30
NUMBER	018	020a	I25	020b	013a	013c	050	019a	028	031	I64	I31
PAGE	3-32	3-34	3-36	3-38	3-40	3-42	3-44	3-60	3-66	3-74	3-78	3-80

JOB TITLE Communication Craftsman

DOT # 822.281

USOE # 16.1501

ALTERNATE TITLES The title should provide entry level information for several  
jobs in the telephone industry including AT&T Long Lines

EMPLOYING INDUSTRIES Telephone Industries

JOB DESCRIPTION:

Works with testing and measuring devices to adjust, maintain and repair communication equipment including telephones, microwave radio, data, televisions and telegraph. Install and repairs components and modules such as switches, relays and amplifiers. Performs routine equipment maintenance. Removes and replaces wire connections on distributing frames and solders wire to terminal lugs in accordance with wiring diagrams. Climbs poles, ladders and works aloft using hand tools. Drives company vehicle. Keeps written work record.

CREDIT: Roy Stonehocker, AT&T Long Lines, Springfield, Illinois.

## SPECIFIC SKILLS REQUIRED:

1. Work safely, using proper safety equipment and following established safety practices, procedures and OSHA Standards.
2. Properly handle delicate parts, equipment, and system components.
3. Read and interpret technical data, schematics, block diagrams, manufacturer's specifications, etc.
4. Identify electrical components by physical characteristics, color codes, symbols, etc.
5. Properly use common hand tools.
6. Properly use common electronic test equipment.
7. Analyze and troubleshoot transistor and tube type RF and audio circuits.
8. Troubleshoot and properly align or calibrate electronic equipment.
  - a. telephone switching circuits
  - b. amplifiers
  - c. relays
9. Remove and replace defective parts and components correctly without damage to other parts.
10. Properly interconnect and interface electronic equipment and circuits.
11. Clearly report findings or changes in technical reports.
12. Work within rules and regulations of the F.C.C.

I.10

0.24

I.11.b

0.16

0.13.a, 0.13.b

I.19.a, I.19.b,

0.19.a, 0.19.b

0.27.a, 0.27.b,

0.28

0.19.c, 0.28,

Plus OJT

0.50

0.22, 0.27.a

0.26

0.25

## RECOMMENDED SCHEDULE OF EDUCATIONAL BLOCKS:

NUMBER	I10	014a	016	015	024	I11b	017	I19a	I19b	I20a	I20b	014b
PAGE	3-4	3-6	3-8	3-12	3-14	3-16	3-20	3-22	3-24	3-26	3-28	3-30
NUMBER	018	020a	I25	020b	013a	013c	050	026	019a	027a	019b	028
PAGE	3-32	3-34	3-36	3-38	3-40	3-42	3-44	3-50	3-60	3-62	3-64	3-66
NUMBER	027b	025										
PAGE	3-70	3-72										

JOB TITLE Audio Visual Technician

DOT # 033.181

USOE # 160108

ALTERNATE TITLES Sound Technician (DOT # 829.281-042)

Audio Video Repairman (DOT # 729.281-010)

EMPLOYING INDUSTRIES Schools, Auditoriums

JOB DESCRIPTION:

Sets up, adjusts, and properly operates public address systems, background music equipment (tape recorders, phonographs, or radio), movie and still picture systems including 16mm, 8mm, slide, and filmstrip projectors. Keeps all systems adjusted for optimum performance under various situations such as outdoor and indoor presentations, different acoustical conditions, and various performance requirements. Makes sure that all levels of sound and presentation are equal to various audience areas. This includes proper placing of speakers and microphones to eliminate feedback but assuming proper amplification of the program. Operates and assembles video tape recording equipment using cameras, monitors, microphones, and lighting to assume proper reproduction of filmed situations. Operates antenna systems to assume proper reception of desired programs. Runs intercom equipment which involves multi-room systems of transmit and receive capabilities. Performs preventive maintenance, troubleshoots, installs and repairs audio visual equipment including opaque and overhead projectors, microfilm readers, and language lab equipment. Has high mechanical abilities and is able to work without direct supervision.

CREDIT: Richard Fisher, Sound Technician, University of Illinois, Urbana, Ill.  
Dennis Riggs, Audio Visual Technician, Parkland College, Champaign,  
Illinois.

## SPECIFIC SKILLS REQUIRED:

- |   |  |
|---|--|
| 1. Work safely, using proper safety equipment and following established safety practices, procedures, and <u>OSHA</u> Standards.    | I.10                                   |
| 2. Properly handle delicate parts, equipment, and system components.  | 0.24                                   |
| 3. Install permanent as well as portable sound systems following applicable codes relating to public rooms, auditoriums and stages. | 0.22, I.12,<br>I.13.a, I.13.b,<br>I.45 |
| a. use proper techniques for open-wire systems.   |  |
| b. use proper techniques for enclosed wiring systems through conduit, walls, floors, and ceilings.                                  |  |
| c. locate and install microphones, speakers, control boards, amplifiers, patch boards, etc.   |  |
| d. prepare and install patch cords, audio cable, control wires, etc.  |  |
| e. interconnect equipment properly, matching impedances, etc.   |  |
| 4. Mix P.A., music and projector systems so they work together to produce desired effect.   | 0.23                                   |
| 5. Produce special audio-visual effects.  | 0.23                                   |
| 6. Locate, read, and interpret technical data, schematics, specifications, etc.   | I.11.a, I.11.b                         |
| 7. Identify electrical components by physical characteristics, color codes, symbols, etc.   | I.16, 0.16                             |
| 8. Properly use common hand tools.  | 0.13.a, 0.13.c                         |
| 9. Properly use common test equipment:  | I.19.a, 0.19.a                         |
| a. VTVM   |  |
| b. oscilloscope   |  |
| c. signal generator   |  |
| d. signal tracer  |  |
| e. tube and transistor checkers   |  |
| f. capacitor testers  |  |
| 10. Identify and troubleshoot common electronic circuits and  | I.20.a, I.20.b,<br>0.20.a, 0.20.b      |
| a. power supplies   |  |
| b. amplifiers   |  |
| c. pre-amps   |  |
| d. mixers   |  |
| e. speakers   |  |
| f. microphones  |  |
| g. wiring systems   |  |
| 11. Identify and troubleshoot common electromechanical equipment:   | 0.23                                   |
| a. audio-visual equipment   |  |
| b. phonographs  |  |
| c. projectors   |  |
| d. tape equipment   |  |
| 12. Secure replacement parts.   | 0.20.b                                 |
| 13. Remove and replace defective parts and components correctly without damage to other parts.                                      | 0.50                                   |
| a. unsolder   |  |
| b. solder   |  |
| Both on hand-wired and printed circuits.  |  |

## RECOMMENDED SEQUENCE OF EDUCATIONAL BLOCKS:

NUMBER	I10	014a	016	015	024	I11b	017	I19a	I20a	I20b	014b	018
PAGE	3-4	3-6	3-8	3-12	3-14	3-16	3-20	3-22	3-26	3-28	3-30	3-32
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PAGE	3-34	3-36	3-38	3-40	3-42	3-44	3-50	3-52	3-54	3-56	3-58	3-82
NUMBER	I12	I13a	013b	I13b	I45							
PAGE	3-86	3-88	3-90	3-92	3-94							

JOB TITLE Home Entertainment Serviceman

DOT # 720.281

USOE # 17.1503

ALTERNATE TITLES Hi-Fi and Stereo Repairman, Serviceman

EMPLOYING INDUSTRIES Hi-Fi and Stereo Stores

JOB DESCRIPTION:

Home entertainment servicemen test, adjust and service phonographs, amplifiers, tuners, tape recorders, scanners and all other entertainment products sold by their employer. The work involves using special test equipment to locate the problem and hand tools to repair or replace the faulty unit or component. Servicemen must be able to diagnose symptoms and verify the suspected faulty unit.

Servicemen must be able to continue their education after their employment. He must attend schools, read literature and otherwise keep abreast of the new developments in his field.

CREDIT: Bob Gattermeir, Team Electronics, Champaign, Illinois.

## SPECIFIC SKILLS REQUIRED:

1. Work safely, using proper safety equipment and following established safety practices, procedures and OSHA Standards.
2. Properly handle delicate parts, equipment, and system components.
3. Locate, read, and interpret technical data, schematics, specifications, service data and manufacturer's bulletins.
4. Identify electrical components by physical characteristics, color codes, symbols, etc.
5. Properly use common hand tools.
6. Use common test equipment:
  - a. VTVM-VOH
  - b. oscilloscope
  - c. A.F. signal generator
  - d. R.F. signal generator
  - e. tube tester
  - f. transistor checker
  - g. logic probes
  - h. capacitor checker
  - i. signal tracer
7. Troubleshoot home entertainment electronic equipment, performing visual inspections and following logical procedures to locate faulty component:
  - a. AM tuners
  - b. FM tuners
  - c. Pre-amplifiers
  - d. amplifiers
  - e. microphones
  - f. speakers
  - g. antenna systems
  - h. stereo sound systems
  - i. quadraphonic sound systems
8. Troubleshoot common electromechanical components to isolate trouble:
  - a. phonographs
  - b. tape decks
  - c. tape cassettes
  - d. turntables
9. Secure replacement parts.
10. Remove and replace defective parts and components correctly without damage to other parts:
  - a. unsolder
  - b. solder

Both on hand-wired and printed circuits.
11. Properly align AM and FM tuners and receivers.
12. Explain the problem and corrective measures taken to the customer and/or supervisor.

I.10

0.24

I.11.b

0.16

0.13.a, 0.13.c

I.19.a, 0.19.a

0.19.b

0.20.a, 0.20.b

0.20, I.18

I.11.b

0.50

0.28

0.80

## RECOMMENDED SEQUENCE OF EDUCATIONAL BLOCKS:

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PAGE	3-66	3-96										

JOB TITLE Radio Repairman (Communications)

DOT # 720.281-010

USOE # 17.1503

ALTERNATE TITLES Radio Troubleshooter, Communications Man, Radio Electrician,  
Communications Serviceman

EMPLOYING INDUSTRIES Large Industry, Public Service, Communications  
Companies, and Radio-TV Shops

**JOB DESCRIPTION:**

Repairs radio receivers, (AM, FM Stereo, Short Wave and CB), portable as well as fixed. Uses test equipment to locate fault. Uses tools to replace, clean or adjust faulty component.

Maintains and services all two-way radio units, communication equipment. Receives wiring diagrams, work orders, and instructions.

Reads and interprets any type of wiring diagram or makes sketches of wiring to aid in reassembly when diagrams are not available. Tests and inspects all communications equipment, two-way radios and communications systems in plant. Repairs instrument meters.

Services and maintains the above equipment by disassembling, replacing, adjusting, fabricating, repairing, fitting and assembling replacement parts as necessary. Changes wiring and characteristics of equipment to suit voltage and other requirements. Services other electronic equipment on occasion. Does on-the-job planning.

Analyzes trouble on emergency breakdowns, cuts out faulty circuits, and makes temporary repairs on equipment still in service to minimize operating delays until such times as the equipment may be more advantageously shut down for complete overhaul.

NOTE: In order to perform the work on the two-way radio's, mobile units and main transmitter, it requires, by F.C.C. regulations, that the repairman must pass the test and receive his license as a "Second Class Radio Operator" from the F.C.C.

CREDIT: Laclede Steel Job Description (Plant Code #12-83), St. Louis, Missouri.  
Richard Fischer, Sound Technician, University of Illinois,  
Urbana, Illinois.

## Radio Repairman (Communications)

### SPECIFIC SKILLS REQUIRED:

1. Work safely, using proper safety equipment and following established safety practices, procedures, and OSHA Standards.
2. Properly handle delicate parts, equipment, and system components.
3. Install and remove mobile as well as base transmitters/receivers, and select and install correct antennas.
4. Tune unit to antenna.
5. Connect remote console through phone lines to transmitter/receiver.
6. Adjust line current for proper frequency selection.
7. Check units for proper output and sensitivity.
8. Read and interpret technical data, schematics, and troubleshooting procedures.
9. Properly use common test equipment:
  - a. oscilloscope
  - b. signal tracer
  - c. signal generator
  - d. tube and transistor checkers
  - e. capacitor testers
  - f. R.F. signal generators
  - g. grid-dip meters
10. Properly use common hand tools.
11. Identify electronic components by physical characteristics, color codes, symbols, etc.
12. Secure replacement parts.
13. Remove and replace defective parts and components correctly without damage to other parts.
  - a. unsolder
  - b. solderBoth on hand-wired and printed circuits.
14. Perform periodic inspection of units (mobile or base) entering into log: power, sensitivity, battery voltage, frequency and test point voltage measurements.
15. Keep transmitter within allowable frequency tolerances.
16. Isolate, repair, and replace faulty components following logical troubleshooting procedures and instruments.
17. Evaluate inter-cabling and unit (mobile or base) for proper operation.
18. Connect units to test jigs, dummy loads, signal generator, watt meter, etc.
19. Properly align units.
20. Analyze transistor and tube type R.F. and audio circuits.
21. Work within rules and regulations of the F.C.C.
22. Install, maintain, and troubleshoot radio controlled equipment, intrusion alarms (sonic alarms), civil defense receivers, handy-talkies, (miniature transmitter/receivers), paging systems, repeaters, etc.

### EDUCATIONAL BLOCKS REQUIRED

I.10

O.24

O.27.a, O.27.b

O.27.a, O.27.b

O.27.a, O.27.b

O.27.b

O.27.b

I.11.b

I.19.a, O.19.a,

O.19.b

O.13.a, O.13.c

O.16.b

I.11.b

O.50

O.27.b

O.27.b

O.20

O.27.b

O.27.b

O.28

O.27.a, O.27.b

O.25

O.27.a, O.27.b

# Radio Repairman (Communications)

## RECOMMENDED SEQUENCE OF EDUCATIONAL BLOCKS:

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JOB TITLE Television Serviceman

DOT # 720.281-018

USOE # 16.0108

ALTERNATE TITLES TV Repairman

EMPLOYING INDUSTRIES TV Repair Shops

**JOB DESCRIPTION:**

Television repairmen test, adjust and service color and black and white television sets. He may also repair AM, FM, FM stereo, quadraphonic and tape units. Some repairmen also work on auto radios and tape decks, electric organs, garage door openers, etc., depending upon the product line. Many repairmen who work for large shops or organizations may specialize in one type of electronic equipment. The work involves using special test equipment to locate faulty components and use hand tools to repair or replace the electronic fault. Because components and leads are color coded, and further, because of the growing number of color TV's, the serviceman is seriously handicapped by a lack of good color vision. Repairmen often need to drive to customer's home for repair, pickup, and delivery, so must be able to drive small truck safely.

CREDIT: Marty Manny, Manny and Wamsley TV, Savoy, Illinois.

## SPECIFIC SKILLS REQUIRED:

1. Work safely, using proper safety equipment and following established safety practices, procedures and OSHA Standards.
2. Properly handle delicate parts, equipment, and system components.
3. Locate, read, and interpret technical data, schematics, specifications, service data, and manufacturer's bulletins.
4. Identify electronic components by physical characteristics, color codes, symbols, etc.
5. Properly use common hand tools.
6. Properly use common test equipment:
  - a. VOM-VTVM
  - b. oscilloscope
  - c. A.F. signal generators
  - d. R.F. signal generators
  - e. tube tester
  - f. transistor checker
  - g. logic probes
  - h. capacitor checker
  - i. signal tracers
  - j. TV analysis
  - k. test jigs and fixtures
  - l. dot and bar generators
  - m. counters
  - n. picture tube tester
  - o. hi voltage probe
  - p. tuner substitutes
7. Troubleshoot common equipment, performing visual inspections, and following logical procedures to locate faulty component:
  - a. color TV
  - b. black and white TV
  - c. AM and FM radios
  - d. FM stereo receivers
  - e. sound systems
  - f. antenna systems
  - g. tape units
8. Properly use cleaners and lubricants.
9. Secure replacement parts and/or equipment substitutions.
10. Remove and replace defective parts and components correctly without damage to other parts:
  - a. unsolder
  - b. solder

Both on hand-wired and printed circuits
11. Isolate and replace faulty modules.
12. Properly align AM, FM, FM stereo, and television receivers.
13. Properly converge color TV.
14. Properly replace picture tubes, flyback transformers, yokes, etc.
15. Explain the problem and corrective measures taken to the customer and/or supervisor.

I.10

0.24

I.11.b

0.16

0.13.a, 0.13.c  
I.19.a, 0.19.a,  
0.19.b

0.27.a, 0.19.c

I.25  
I.11.b  
0.50

0.20  
0.28  
0.28  
0.50, 0.19.c

0.80

## RECOMMENDED SEQUENCE OF EDUCATIONAL BLOCKS:

NUMBER	I10	014a	016	015	024	I11b	017	I19a	I20a	I20b	014b	018
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NUMBER	020a	I25	020b	013a	013c	050	026	019a	027a	019b	028	019c
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NUMBER	080											
PAGE	3-96											

JOB TITLE Audio Director

DOT # 957.282

USOE # 16.0108

ALTERNATE TITLES Sound Man, Stage Hand, Electronic Sound Manipulator,  
Studio Electrician (17.1002)

EMPLOYING INDUSTRIES Theatres, Performing Arts

JOB DESCRIPTION:

From the script, the director, and rehearsals, the audio director determines the audio requirements. He installs, adjusts and maintains the required audio equipment. He works with intercoms, PA systems, sound reinforcement systems, recording studios and theatre sound systems. He must properly place microphones and speakers of several audio systems to achieve the desired effect and prevent cross coupling, feedback and dead spots. He operates and monitors the sound (audio) controls during the performance reacting to cues of the director and script. He operates the recording studio during recording of live performances or sessions. He operates recording equipment to achieve proper recording level mixing and fading. He must keep all systems adjusted for best performance considering the accoustical requirements and environment. He operates and maintains the audio systems. He must work well with people and have an appreciation for the performing arts.

CREDIT: W. Nash, Building Supervisor, Krannert Center, University of Illinois,  
Urbana, Illinois.  
Tom Hays, Audio Director, Krannert Center, University of Illinois,  
Urbana, Illinois.

## SPECIFIC SKILLS REQUIRED:

- |   |  |
|---|--|
| 1. Work safely, using proper safety equipment and following established safety practices, procedures, and <u>OSHA</u> Standards.                        | I.10   |
| 2. Install permanent as well as portable sound systems following applicable codes relating to public rooms, auditoriums and stages.                     | 0.23, 0.22,<br>I.13.a, 0.13.b,<br>I.13.b, I.45 |
| a. use proper techniques for open-wire systems.   |  |
| b. use proper techniques for enclosed wiring systems through conduit, walls, floors, and ceilings.  |  |
| c. locate and install microphones, speakers, control boards, amplifiers, patch boards, etc.   |  |
| d. prepare and install patch cords, audio cable, control wires, etc.  |  |
| e. interconnect equipment properly, matching impedances, etc.   |  |
| 3. Satisfy stage and audience sound requirements while avoiding common problems such as dead spots, cross coupling, feedback, excess power demand, etc. | 0.22   |
| 4. Read a script, follow a performance, as well as to take or give cues.  | 0.22, OJT                                      |
| 5. Produce special audio effects.   | 0.22   |
| 6. Operate an audio board.  | 0.22   |
| 7. Patch an audio patch panel.  |  |
| 8. Locate, read, and interpret technical data, schematics, specifications, etc.   | I.11.b   |
| 9. Identify electrical components by physical characteristics, color codes, symbols, etc.   | 0.16   |
| 10. Properly use common hand tools.   | 0.13.a, 0.13.b,<br>0.13.c<br>0.19.a            |
| 11. Properly use common test equipment:   |  |
| a. VTVM   | d. signal generator                            |
| b. oscilloscope   | e. tube and transistor checkers                |
| c. signal tracer  | f. capacitor testers                           |
| 12. Identify and troubleshoot common electronic circuits and equipment:   | 0.18, 0.20.a,<br>0.25, 0.20.b                  |
| a. power supplies   | e. speakers                                    |
| b. amplifiers   | f. microphones                                 |
| c. pre-amps   | g. wiring systems                              |
| d. mixers   |  |
| 13. Identify and troubleshoot common electromechanical equipment:   | I.18, I.23                                     |
| a. phonographs  |  |
| b. projectors   |  |
| c. tape equipment   |  |
| 14. Secure replacement parts.   | I.11.b   |
| 15. Remove and replace defective parts and components correctly without damage to other parts.  | 0.50   |
| a. unsolder   |  |
| b. solder   | Both on hand-wired and printed circuits.       |

## RECOMMENDED SEQUENCE OF EDUCATIONAL BLOCKS:

NUMBER	I10	O14a	O16	O15	O24	I11b	O17	I19a	I20a	I20b	O14b	O18
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JOB TITLE Radio Broadcast Engineer

DOT # 957.282-018

USOE # 16.0108

ALTERNATE TITLES Broadcast Technician, Control Room Technician,  
Audio Engineer

EMPLOYING INDUSTRIES Radio Stations

JOB DESCRIPTION:

The engineer has to take meter readings and keep transmitter tuned. Maintains the proper phasing of the directional antenna system. Operates audio board, tape decks, cartridge machines, remote amplifier and automation equipment. Does maintenance on the transmitter, audio equipment, monitors, automation equipment, amplifiers, tape decks, cartridge machines and turntables. Sets up remote operation. Programs the automation system. Winds new tape on cartridges. Does production of commercials. Designs and builds electronic circuits. Fills out operation and maintenance logs and writes reports.

Must have a F.C.C. Radio Telephone Operator License. Must be willing to work odd hours and weekends. Must be able to work well with people under pressure and to make quick decisions that affect quality of broadcast program. The engineer often works alone so needs to be able to work without direct supervision.

CREDIT: Eugene Bamert, Broadcast Engineer, WDWS, Champaign, Illinois.

## SPECIFIC SKILLS REQUIRED:

- |   |  |
|---|--|
| 1. Work safely, using proper safety equipment and following established safety practices, procedures, and <u>OSHA</u> Standards.  | I.10                                     |
| 2. Properly handle delicate equipment, parts, and system components.  | 0.24                                     |
| 3. Work within confines of applicable F.C.C. rules and regulations.   | 0.25                                     |
| 4. Write reports and make proper entries in station logs.   | 0.26                                     |
| 5. Read meters and monitors, and make proper adjustments to equipment on the basis of readings.                                   | 0.27.b, OJT                              |
| 6. Monitor multiple programs.   | 0.22                                     |
| 7. Operate an audio board, patch panel, microphones, tape decks, turntables, carousels, automated tape systems, and patch boards. | 0.22, OJT                                |
| 8. Properly use common hand tools.  | 0.13.a, 0.13.c                           |
| 9. Locate, read, and interpret technical data, schematics, specifications, etc.   |  |
| 10. Identify electronic components by physical characteristics, color codes, symbols, etc.  | 0.16                                     |
| 11. Properly use common test equipment:   | I.19, 0.19                               |
| a. VTVM, VOM  | e. capacitor checker                     |
| b. scope  | f. frequency counter                     |
| c. AF signal generator  | g. grid dip meter                        |
| d. tube and transistor checker  | h. distortion analyzer                   |
|   | i. RF signal generator with sweep        |
| 12. Identify and troubleshoot electronic circuits and equipment as used in the broadcast industry:                                | 0.20, 0.27.b, OJT                        |
| a. AM and FM transmitters   | f. photo cells                           |
| b. AM and FM antennas and transmission lines  | g. amplifiers                            |
| c. bridging transformers  | h. mixers                                |
| d. time gates   | i. microphones                           |
| e. stereo signal generators   | j. audio boards                          |
| 13. Identify and troubleshoot common electromechanical equipment used in the broadcast industry:                                  | 0.20.a, 0.20.b<br>I.18, I.23             |
| a. tape decks   | c. carousels                             |
| b. turntables   | d. automation systems                    |
| 14. Secure replacement parts.   | I.11.b                                   |
| 15. Remove and replace defective parts and components correctly without damage to other parts:                                    | 0.50                                     |
| a. unsolder   |  |
| b. solder   | Both on hand-wired and printed circuits. |
| 16. Prototype and build special circuits.   | 0.29                                     |

## RECOMMENDED SEQUENCE OF EDUCATIONAL BLOCKS:

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JOB TITLE Broadcast Engineer - Television

DOT # 957.282-018

USOE # 16.0108

ALTERNATE TITLES Broadcast Technician, Control Room Technician,

Master Control Engineer

EMPLOYING INDUSTRIES TV Broadcast Stations

**JOB DESCRIPTION:**

The TV studio engineer is an electronics technician with duties in production and equipment maintenance. His duties in program operation include technical directing, which includes controlling the video signal on the air, video tape operations, recording programs and commercial productions.

Engineers are responsible for the quality of the signal that is broadcast. Their duties include operating the more sophisticated equipment in the studio, such as video-tape recorders, cameras, video switchers and audio recorders and consoles. The broadcast industry describes this work as "production" which may be live, such as a newscast, or a pre-recorded production, such as a commercial.

TV technicians also troubleshoot and perform preventive maintenance on the equipment in the studio and at the transmitter. He is also responsible for audio operations which consists of previewing and cueing audio tapes for air playback. The audio operator also mixes the sound for commercial productions and live programs such as newscasts. These engineers also must keep records called operation logs as required by the F.C.C. These logs tell the exact times that all the programs and commercials ran. All engineers perform maintenance and troubleshooting equipment in need of repair. There are also transmitter engineers who monitor the signals and keep operation logs.

The engineer must be able to work well with others in a stress-filled atmosphere and must have good hand-eye coordination, good reflexes, hearing, and color vision.

CREDIT: James Davey, TV Broadcast Engineer, WCIA, Champaign, Illinois.  
Marty Manney, Former TV Broadcast Engineer, WCIA, Champaign, Illinois.

## SPECIFIC SKILLS REQUIRED:

- |   |  |
|---|--|
| 1. Work safely, using proper safety equipment and following established safety practices, procedures, and <u>OSHA</u> Standards..   | I.10                                     |
| 2. Properly handle delicate equipment, parts, and system components.  | 0.24                                     |
| 3. Work within confines of applicable F.C.C. rules and regulations.   | 0.25                                     |
| 4. Write reports and make proper entries in station logs.   | 0.26                                     |
| 5. Read meters and monitors, and make proper adjustments to equipment on the basis of readings.   | 0.27.b                                   |
| 6. Monitor multiple programs.   |  |
| 7. Operate audio board, patch panel, tape decks, carousels, automated tape systems, cartridge tape recorders and players, video amplifiers and distribution, video switching devices, slide projectors, movie projectors, tape recorders and monitors, microwave exciters and receivers, etc. | 0.22, 0.27.b,<br>OJT                     |
| 8. Properly use common hand tools.  | 0.13.a, 0.13.c                           |
| 9. Locate, read, and interpret technical data, schematics, specifications, block diagrams, etc.   | I.11.b                                   |
| 10. Identify electronic components by physical characteristics, color codes, symbols, etc.  | 0.16                                     |
| 11. Properly use common test equipment:   | I.19, 0.19                               |
| a. VTVM, VOM  | f. frequency counter                     |
| b. scope  | g. grid dip meter                        |
| c. AF signal generator  | h. distortion analyzer                   |
| d. tube and transistor checker  | i. RF signal generator with sweep        |
| e. capacitor checker  | j. vectorscope                           |
| 12. Adjust and troubleshoot electronic circuits and equipment as used in the TV broadcast industry:   | 0.20, 0.27.b<br>OJT                      |
| a. AM and FM transmitters.  |  |
| b. AM and FM antennas and transmission lines.   |  |
| c. bridging transformers.   |  |
| d. time gates.  |  |
| e. cartridge audiotape players and recorders.   |  |
| f. reel-to-reel audiotape players and recorders.  |  |
| g. audio amplifiers and distribution systems.   |  |
| h. video amplifiers and distribution systems.   |  |
| i. video switching devices  |  |
| j. slide and movie projectors.  |  |
| k. color and monochrome cameras (30th studio and film).   |  |
| l. sync generators.   |  |
| m. color frequency standard.  |  |
| n. video tape recorders.  |  |
| o. color and monochrome monitors.   |  |
| p. microwave transmitters and receivers (STL's).  |  |
| 13. Secure replacement parts.   | I.11.b                                   |
| 14. Remove and replace defective parts and components correctly without damage to other parts:  | 0.50                                     |
| a. unsolder   |  |
| b. solder   | Both on hand-wired and printed circuits. |
| 15. Prototype and build special circuits.   | 0.29                                     |
| 16. Properly place lighting.  | I.33                                     |
| 17. Set up and operate remote installations.  | 0.27                                     |

RECOMMENDED SEQUENCE OF EDUCATIONAL BLOCKS:

NUMBER	I10	O14a	O16	O15	O24	I11b	O17	I19a	I20a	I20b	O14b	O18
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JOB TITLE Electronics Technician DOT # 003.181-014

USOE # 16.0108

ALTERNATE TITLES Electronics Equipment Technician, Electronics  
Engineering Technician

EMPLOYING INDUSTRIES Most Industries

COMMENT: This occupation requires a minimum of two years post-high school training.

**JOB DESCRIPTION:**

Under general direction, performs highly skilled technical work in the evaluation, design, construction and maintenance of electronic equipment and systems; oversees the use and maintenance of all electronic equipment and supervises the work of subordinates engaged in those functions; evaluates accuracy of commercially manufactured equipment and makes recommendations regarding its purchase; and is responsible for the proper use, maintenance, and repair of electronic equipment.

Confers with research investigators to determine electronic equipment requirements in terms of specific functions desired and degree of accuracy required. From the requirements set by investigators, arranges various types of equipment or components into electronic systems or adapts specific pieces of equipment to perform in accordance with the pre-set criteria.

Given schematic diagram of proposed piece of equipment, breadboards, tests, modifies, prototypes, and final tests equipment. Makes recommendations regarding design and/or modifications.

This job requires extensive knowledge of electronic components, circuits, systems and equipment, as well as the proper use and maintenance of equipment and systems.

Requires ability to understand complex electronic relationships, diagnose malfunctions and make repairs.

Requires ability to understand purposes and objectives of research projects and to design and develop electronic systems or make adaptations to systems and equipment to perform the desired function within specific limits of accuracy.

Requires ability to supervise subordinates in the use, repair, and maintenance of equipment, and the ability to work without direct supervision.

May need to write technical reports and papers communicating the results of work done or findings made. May be involved in the specification and purchasing of components and equipment.

CREDIT: University of Chicago Job Description, Chicago, Illinois.  
City of Chicago Job Description Code 2040, Chicago, Illinois.  
State of Illinois, Department of Personnel Job Description,  
Spec. Code 3145, Position Code 13360, Springfield, Illinois.  
Honeywell-Micro Switch Position Specification, Freeport, Illinois.

# Electronics Technician

## SPECIFIC SKILLS REQUIRED:

1. Work safely, using proper safety equipment and following established safety practices, procedures and OSHA Standards.
2. Properly handle delicate parts, equipment, and system components.
3. Read and interpret technical data, schematics, block diagrams, manufacturer's specifications, etc.
4. Identify electrical components by physical characteristics, color codes, symbols, etc.
5. Properly use common hand tools.
6. Properly use common electronic test equipment.
7. Test design theories by breadboarding electronic circuits from schematic diagram.
8. Construct and test prototype circuits.
9. Modify electronic circuit designs to produce desired response or output.
10. Troubleshoot and properly align or calibrate sophisticated electronic equipment.
11. Remove and replace defective parts and components correctly without damage to other parts.
12. Modify or make adaptations to systems and equipment to meet specifications.
13. Select equipment on basis of system needs.
14. Prepare layout and detail designs of mechanical hardware, electronic circuits, printed circuit boards, and other items as well as to arrange for their fabrication.
15. Assure parts are assembled according to prints and conduct trial production runs.
16. Anticipate problems that may occur in new equipment.
17. Properly interconnect and interface electronic equipment and circuits.
18. Keep abreast of state-of-the-art components systems, and techniques.
19. Clearly report findings or changes in technical reports.
20. Work in close contact with production, quality control, and purchasing departments, to coordinate project work.

## EDUCATIONAL BLOCKS REQUIRED

I.10  
0.24  
I.11  
I.16, 0.16  
0.13  
I.19, 0.19  
0.29  
0.29  
I.20  
0.20, 0.28  
0.50  
\*  
\*  
I.11  
\*  
\*  
\*  
\*  
0.26  
\*

\* Beyond the scope of a high school program

NOTE: This occupation requires post-high school education for entry level employment. However, the following sequence, in conjunction with math and science courses will make transfer to the post-high school institution much smoother, even permitting advanced standing in many cases.

## RECOMMENDED SEQUENCE OF EDUCATIONAL BLOCKS:

NUMBER	I10	014a	016	015	024	I11b	017	I19a	I20a	I20b	014b	018
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NUMBER	020a	I25	020b	013a	013c	050	029	019a	080			
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JOB TITLE Avionics Technician

DOT #                     

USOE # 16.0108

ALTERNATE TITLES Aircraft Electronics Technician

EMPLOYING INDUSTRIES Airports, Repair and Maintenance Shops

**JOB DESCRIPTION:**

The avionics technician must be a highly trained, skilled technician well aware of the consequences of sloppy workmanship. He repairs radio and radar transmitters and receivers for aircraft landing, communication, tracking and navigation systems. Uses test equipment to locate fault and common hand tools to replace, adjust and clean faulty component. Performs periodic checks and runs scheduled maintenance procedures. Works on board ship to install, remove and repair aircraft electrical and electronic equipment in accordance with FAA standards and practices. Performs some work on ship in tight quarters. Services and maintains equipment by disassembling, replacing, adjusting, repairing, fitting and assembling replacement parts as necessary. Reads and interprets aircraft structural drawings as well as wiring diagrams and schematics. He works for an FAA certified repair shop and as a result is certified himself for working in that shop.

- NOTE: (1) This job is a specialization that should follow the training for electronics technician.
- (2) Although an F.C.C. license is not needed to work in an F.A.A. shop, it is felt that the First Class Commercial License would be a desirable credential to have when seeking employment.

CREDIT: Guidance Centre, University of Toronto, Toronto, Ontario, Canada.

## SPECIFIC SKILLS REQUIRED:

EDUCATIONAL  
BLOCKS  
REQUIRED

- |  |  |
|--|--|
| 1. Work safely, using proper safety equipment and following established safety practices, procedures and <u>OSHA</u> Standards.                                  | I.10                                     |
| 2. Properly handle delicate parts, equipment, and system components.   | 0.24                                     |
| 3. Install and remove electronics units from aircraft and select and install antennas.   | *  |
| 4. Tune units to antennas.   | 0.28, *                                  |
| 5. Check aircraft electronics systems for proper alignment, sensitivity and power output.  | *0.28, *                                 |
| 6. Read and interpret technical data, schematics, block diagrams, manufacturer's specifications including air-frame drawings.                                    | I.11.b                                   |
| 7. Identify electrical/electronic components by physical characteristics, color codes, symbols, etc.   | I.16, 0.16                               |
| 8. Properly use common hand tools including torque wrench.   | 0.13.a, 0.13.b                           |
| 9. Properly use common electronic test equipment:  | I.19.a, 0.19                             |
| a. VTVM  | h. grid-dip meters                       |
| b. oscilloscope  | i. logic probes                          |
| c. signal tracer   | j. test jibs and fixtures                |
| d. signal generator  | k. counters                              |
| e. tube and transistor checkers  | l. dummy loads                           |
| f. capacitor testers   | m. watt meters                           |
| g. H.F. signal generators  |  |
| 10. Troubleshoot and properly align or calibrate sophisticated electronic aircraft comm-nav systems.   | * , OJT                                  |
| a. communications transmitters   | h. absolute ground speed indicators      |
| b. communications receivers  | i. automatic pilot systems               |
| c. OMNI systems (V.O.R.)   | j. distance measuring equipment (D.M.E.) |
| d. transponders  | k. gyros                                 |
| e. R.D.F., A.D.F. systems  | l. I.L.S. systems                        |
| f. automatic landing systems   |  |
| g. electronic altimeters   |  |
| 11. Secure replacement parts.  | I.11.b                                   |
| 12. Remove and replace defective parts and components correctly without damage to other parts.   | 0.50                                     |
| a. unsolder  |  |
| b. solder  | Both on hand-wired and printed circuits. |
| 13. Perform periodic inspection of units (mobile or base) entering into log: power, sensitivity, battery voltage, frequency and test point voltage measurements. | Q.27.b                                   |
| 14. Keep transmitters within allowable frequency tolerances.   | 0.27.b                                   |
| 15. Properly interconnect and interface equipment (intercabling) for proper operation.   | *  |
| 16. Work within F.C.C. and F.A.A. rules and regulations.   | 0.25                                     |
| 17. Make proper entries into logs.   | 0.26                                     |
| 18. Must be able to work on sub-miniature units.   | 0.24                                     |
| 19. Keep abreast of state-of-the-art components systems, and techniques.   | *  |
| 20. Explain problem and corrective measures to customer and/or supervisor.   | 0.80                                     |

\* Beyond the scope of the high school program.

NOTE: This occupation requires post-high school education for entry level employment. However, the following sequence, in conjunction with solid math and science courses will make transfer to the post-high school institution much smoother, even permitting advanced standing in many cases.

RECOMMENDED SEQUENCE OF EDUCATIONAL BLOCKS:

NUMBER	I10	014a	016	015	024	I11b	017	I19a	I20a	I20b	014b	018
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NUMBER	020a	I25	020b	013a	013c	050	029	026	019a	027a	019b	028
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NUMBER	027b	025	031	080								
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# CROSS REFERENCE OCCUPATIONS / EDUCATIONAL

## EDUCATIONAL BLOCKS

## OCCUPATIONS

	SAFETY, 110	BASIC ELECTRIC PARAMETERS, 014A	ELECTRONIC COMPONENT IDENTIFICATION, 016	CIRCUIT CONFIGURATIONS, 015	DELICATE PARTS & EQUIPMENT, 024	DRAWINGS & SPECS (ELECTRONIC), 111B	FUNCTIONS OF ELECTRONIC COMPONENTS, 017	INSTRUMENTS & MEASUREMENTS I, 119A	INSTRUMENTS & MEASUREMENTS II, 119B	ELECTRIC TROUBLESHOOTING I, 120A	ELECTRIC TROUBLESHOOTING II, 120B	ELECTRONIC CIRCUIT FUNDAMENTALS, 018	ELECTRONIC TROUBLESHOOTING I, 020A	CLEANERS & LUBRICANTS, 125	ELECTRONIC TROUBLESHOOTING II, 020B	HAND TOOLS & HARDWARE I, 013A	TOOLS III (ELECTRIC), 013C	SOLDERING SKILLS, 050	BREADBOARD & PROTOTYPE, 029	ELECTRONIC ASSEMBLY SKILLS, 070	LOGS & REPORTS, 025
ELECTRONICS ASSEMBLER	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
INSTRUMENT REPAIRMAN	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
COMMUNICATIONS CRAFTSMAN	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AUDIO VISUAL TECHNICIAN	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HOME ENTERTAINMENT SERVICEMAN	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
RADIO REPAIRMAN (COMMUNICATIONS)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TV SERVICEMAN	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AUDIO DIRECTOR	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
RADIO BROADCAST ENGINEER	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TV BROADCAST ENGINEER	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ELECTRONIC TECHNICIAN	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
AVIONICS TECHNICIAN	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

VOLS III (ELECTRIC), 013C	
SOLDERING SKILLS, 050	
BREADBOARD & PROTOTYPE, 028	
ELECTRONIC ASSEMBLY SKILLS, 070	
LOGS & REPORTS, 026	
AC MOTORS & ALTERNATORS, 118	
MOTOR OVERHAUL & REPAIR, 123	
AUDIO-VISUAL SKILLS, 023	
AUDIO SYSTEMS, 022	
INSTRUMENTS & MEASUREMENTS III, 019A	
R.F. SYSTEMS I, 027A	
INSTRUMENTS & MEASUREMENTS IV, 019B	
ALIGNMENT & CALIBRATION, 028	
INSTRUMENTS & MEASUREMENTS V, 019C	
R.F. SYSTEMS II, 027B	
FCC FIRST CLASS LICENSE, 025	
INSTRUMENTATION SYSTEMS, 031	
PLUMBING, 164	
INSTALL & READ RECORDERS, 131	
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ELECTRICAL CODES, 112	
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TOOLS II, 013B	
WIRING II, 113B	
REWIRE & MODIFY, 145	
CUSTOMER RELATIONS, 080	

# EDUCATIONAL BLOCKS

	BLOCK NO.	PAGE NO.
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Component Identification	0.16	3-8
Circuit Configurations	0.15	3-12
Handle Delicate Parts and Equipment	0.24	3-14
Drawings and Specifications (Electronics)	I.11.b	3-16
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Instruments and Measurements II	I.19.b	3-24
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Electric Troubleshooting II	I.20.b	3-28
Electrical Parameters II	0.14.b	3-30
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Electronic Troubleshooting I	0.20.a	3-34
Cleaners and Lubricants	I.25	3-36
Electronic Troubleshooting II	0.20.b	3-38
Hand Tools and Hardware I	0.13.a	3-40
Tools III (Electronic)	0.13.c	3-42
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Electronic Assembly Skills	0.70	3-48
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	BLOCK NO.	PAGE NO.
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Rewire and Modify	I.45	3-94
Customer Relations	0.80	3-96

- NOTES: 1. Safety is so broad that the instructor must limit the scope by using typical examples.
2. Safety should be covered as a separate block as well as periodically during the course and during specific tool usage.

- REFERENCES: 1. American Red Cross, ed. Basic First Aid.
2. Illinois Power Company. Safety Manual.
3. Maine State Department of Education. Industrial Electricity Curriculum Manual.
4. National Safety Council. Posters, brochures.
5. Ohio Trade and Industrial Education Service. Electric Lineman.
6. Zbar, Paul B. Electricity-Electronics Fundamentals.

GENERAL OBJECTIVE: Work safely using proper safety equipment and following established safety practices, procedures and OSHA Standards.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Know first aid procedures.	First Aid (including artificial resuscitation)	8 hrs.
Identify first aid equipment and associate with proper usage.	Safety Equipment Blankets Stretchers Powder Fire Extinguisher First Aid Kit	3 hrs.
Know basic safety hazards and practices which exist in industry.	Basic Accident Prevention Safety Hazards Electrical Mechanical Chemical Heights Lifting Safety Practices Safety Equipment Glasses Hard Hats Safety Shoes Masks Tool Usage	4 hrs.
Show or exhibit safety awareness and responsibility.	Safe Working Environment Accidents Reports Results of Not Following Safety Rules	
Know about safety rules that apply or may apply to local industries.	Safety Rules and Regulations General Color Codes Symbols	

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME
Know OSHA requirements for local industry.	OSHA Regulations Inspections Reporting Requirements	2 hrs.
Know and be able to explain the safety rules, regulations and practices according to the applicable source.	Industrial Safety (Typical Example) Job Related Safety Rules Location of Safety Rules Failure to Comply with Safety Rules Safety Training Program	4 hrs.
Know the safety practices and equipment to be used when the voltage exceeds 500 volts.	Above 500 Volts Basic Safety Hazards and Practices Safety Rules Safety Equipment Rubber Blankets Rubber Sleeves Rubber Hoods Hot Sticks	2 hrs.
Consumer product safety.	Consumer Safety Guidelines Grounding Shorts Interlocks Fusing Polarization Radiation	2 hrs.

**SUGGESTED PROCEDURE:**

1. Use typical industries to illustrate those sections of the outline which would otherwise be too broad in scope.
2. Students should be required to take a first aid course.
3. Obtain and use industrial safety posters.
4. Schedule safety meetings once a month and then cover safety as it relates to the material being covered.
5. OSHA requirements are administered by: OSHA, Regional Office, 848 Federal Office Building, 219 S. Dearborn, Chicago, Illinois 60604.
6. Call on industrial safety people for guest presentations.
7. Many electricity or electronic lab books have sections on safety.
8. A Red Cross programmed first aid course (8 hrs.) is particularly useful.
9. Use examples and case histories showing the results of negligence.
10. Use media materials as listed in EIA - Electronics Multi-Media Handbook. Irving W. Larson, ed.

NOTES: This block might well be done concurrently with I.19.a (Instruments and Measurements I) so that the student measures these parameters as he is exposed to each in turn.

- REFERENCES: 1. Devito, M. Introduction to Electricity-Electronics.  
 2. Grob, Bernard. Basic Electronics.  
 3. Malvino, Albert P. Electronic Principles.  
 4. Zbar, Paul B. Basic Electricity.

GENERAL OBJECTIVE: Define basic electrical parameters, their characteristics, units and inter-relationships; determining unknowns when given sufficient knowns.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Define and characterize voltage.	Voltage as a Force Across Two Points Polarity (+) and (-) Magnitude Constant: DC Repetitive: AC, etc. Period Frequency $E_{RMS}$ Units $\mu$ volts m volts K volts M volts	15 hrs.
Define and characterize current.	Current as the Rate of Directional Drift of Charge Through a Circuit Element Direction Magnitudes Constant: DC Repetitive: AC, etc. Period Frequency $I_{RMS}$ m amps $\mu$ amps	6 hrs.
Define and characterize resistance.	Resistance as Opposition to Flow of Current OHMS K OHMS M OHMS	3 hrs.
Define and characterize power.	Power as Rate of Consumption of Energy m Watts Watts K Watts	3 hrs.

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Determine voltage, given current and resistance.  Determine current, given voltage and resistance.  Determine resistance, given voltage and current.  Determine power, given voltage and current.  Determine current, given power and voltage.  Determine voltage, given power and current.  Determine frequency, given period.	Inter-relationships Ohms Law Watts Law Frequency vs. Time Methods of Solving for Unknowns Algebraic Manipulations Use of Nomographs	15 hrs.

SUGGESTED PROCEDURE:

1. If the mathematics background of student group precludes the use of algebra in calculation of unknown parameters, it is recommended that the use of nomographs such as those found in the Appendix be used, or teach the math as needed.
2. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
Irving W. Larson, ed.



UPON COMPLETION OF THIS  
BLOCK, THE STUDENT WILL:

RECOMMENDED TOPICAL  
OUTLINE:

RECOMMENDED  
TIME:

Resistors	2 hrs.
Types	
Carbon Composition	
Wire Wound	
Deposited Film	
Color Code	
Tolerances	
Wattage	
Potentiometers	
Rheostats	
Capacitors	2 hrs.
Types	
Paper	
Ceramic	
Mica	
Electrolytic	
Values	
Ratings and DCWV	
Tolerances	
Color Code	
Variable Types	
Inductors	
Types	
Value	
DC Resistance	
DC Maximum Current	
Transformers	2 hrs.
Types	
Power	
Audio	
Coupling	
Tuned	
Adjustable	
Multiple Winding	
Ratings	
Vacuum Tubes	2 hrs.
Types	
Numbering System	
Multiple	
Special	
Semiconductor Devices	4 hrs.
Diodes	
Special Diodes (Zener, Tunnel, etc.)	
Transistors (BJT's, FET's, etc.)	
Switches (SCR's, DIACS, TRIACS, etc.)	
I.C.'s	
Miscellaneous	8 hrs.
Bulbs	
Antennas	

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
	Microphone Speakers Solenoids Crystals Batteries Photocells Thermocouples Motors	

SUGGESTED PROCEDURE:

1. The instructor should have typical examples of these devices for student practice in identification. They can be loose, mounted with the appropriate symbol given, or mounted on display boards for student use.
2. Use catalogs to locate replacement parts such as those listed under references.
3. Schools should provide trade journals and magazines.
4. Clip coupons out of trade magazines to get free information.
5. Use media materials as listed in EIA - Electronics Multi-Media Handbook. Irving W. Larson, ed.

NOTES: The treatment of these topics should be kept from getting excessively quantitative. This is not meant to be a first course in rigorous network analysis.

- REFERENCES:
1. Devito, M. Introduction to Electricity-Electronics.
  2. Grob, Bernard. Basic Electronics.
  3. Malvino, Albert P. Electronic Principles.
  4. Siskind, Charles S. Electrical Circuits.

GENERAL OBJECTIVE: Demonstrate knowledge of series, parallel, series-parallel, and three phase circuits by determining unknown parameters.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Analyze series circuits to determine unknown parameters.	Series Circuits Common Current Equivalent R Voltage Drops Polarity Magnitudes Kirchoff's Voltage Law Power	3 hrs.
Analyze parallel circuits to determine unknown parameters.	Parallel Circuits Common Voltage Equivalent R Branch Currents Direction Magnitudes Kirchoff's Current Law Power	3 hrs.
Analyze series-parallel circuits to determine unknown parameters.	Series-Parallel Circuits Circuit Simplification Series Elements Parallel Elements Total Resistance Source Current Voltage Drops Branch Currents Power	3 hrs.
Analyze three-phase circuits to determine unknown parameters.	Three-Phase Circuits Y Connection Δ Connection Balanced Loads Load Voltages Load Currents Line Voltages Line Currents Unbalanced Loads Load Voltages Load Currents Line Voltages Line Currents	4 hrs.

SUGGESTED PROCEDURE:

1. In order to facilitate the students mastery of this material, much of the outline should be treated by demonstration and laboratory activity.
2. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
Irving W. Larson, ed.

TITLE: Handle Delicate Parts and Equipment

EDUCATIONAL

BLOCK

0.24

NOTES: This block is intended to caution the student against abusive treatment of electronic equipment.

REFERENCES: Manufacturer's Instruction Manuals for Equipment on Hand.

GENERAL OBJECTIVE: Properly handle delicate equipment, parts, and system components.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Take sufficient precaution to prevent damage as a result of physical influences.	Shock (physical) Vibration Moisture Heat Dirt Bending and Flexing	4 hrs.
Prevent damage to equipment parts and components as a result of electrical influences.	Over Voltage Improper Frequency Improper Grounding Surges Over Driving Over Loading Electrical Contact and Terminal Charge Polarity Shorting Impedance Switching	8 hrs.

**SUGGESTED PROCEDURE:**

1. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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TITLE: Drawings and Specifications (Electronics)

EDUCATIONAL

BLOCK

I.11.b

NOTES: Because of the preponderance of specialized terminology, abbreviations, and acronyms in the field of electronics, these should be given special emphasis throughout any program in electronics.

- REFERENCES:
1. Baer, Charles J. Electrical and Electronics Drawing.
  2. Middleton, Robert G. Electrical and Electronic Signs and Symbols.
  3. Radio Shack Electronics Data Handbook.
  4. Radio Shack Electronics Dictionary.
  5. Shiers, George. Electronic Drafting.

GENERAL OBJECTIVE: Read and interpret conventional drawings, schematics, and specifications encountered on the job.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Identify and describe conventional types of drawings; diagrams, graphs and charts typically encountered in electronics.	Types of Drawings Block Diagrams Functional Diagrams Schematics Wiring Diagrams Component Layout Circuit Pattern Truth Tables Graphs and Charts Bar and Pie Charts Volt-Ampere Graphs Characteristic Curves Nomographs	8 hrs.
Read and use standard electronic symbols. Know that variations do exist from industry to industry.	Symbols - See Appendix	2 hrs.
Read and interpret standard electronic terminology, abbreviations, and acronyms.	Glossary of Electronics Terms	Continuous
Read and interpret standard drawings, diagrams and charts used in electronics.	Conventions of Electronics Drawings Lines Lettering Title Blocks Notes Dates and Revisions Bill of Materials Model and Serial Number. Sequence of Signal Operations Mechanical Linkages Component Values Horizontal Signal Flow Vertical Power Flow	4 hrs.

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Identify and describe standard types of specifications encountered in the electronics industry.	Ground or Common at Bottom Labeling of Test Points, Pin Locations, etc. Symmetry Specifications Types of Specifications Design Operating Performance	1 hr.
Define conventional specifications for electronics equipment.	Specifications Content Input Current Voltage Power Ripple Frequency Sensitivity Selectivity Output Current Voltage Power Frequency Response Waveshape Gain Stability Separation Level Accuracy Precision Environmental Temperature Vibration Humidity Shock Accelleration Mounting Specifications	4 hrs.
Draw sketches of electronic circuits and systems using conventional practices.	Sketching	10 hrs.
Locate replacement parts using catalogs from suppliers.	Catalog Usage with Typical Examples	1 hr.

**SUGGESTED PROCEDURE:**

1. The instructor should obtain a wide assortment of different types of drawings, diagrams, specification sheets, etc. so that the students get as wide an exposure to the various types as possible.

## Drawings and Specifications (Electronics)

### I.11.b

2. The student should secure a good glossary or dictionary of electronic terminology, available from several parts houses. Further, he needs at this point a diagram of typical symbols used in electronics. See Appendix.
3. Building an electronic kit or project would help illustrate this material. Caution: The kit should take a minimal amount of time.
4. Use media materials as listed in EIA - Electronics Multi-Media Handbook. Irving W. Larson, ed.

NOTE: This block might well be sequenced in conjunction with Block 0.16 (Component Identification) so that the student learns to recognize components and their symbol as he learns their functions.

- REFERENCES: 1. Churchman, L. Survey of Electronics.  
 2. Grob, Bernard. Basic Electronics.  
 3. Sands, Leo G. Electronics Handbook for the Technician.

GENERAL OBJECTIVE: Demonstrate knowledge of the functions and applications of common circuit components by locating faults in each under typical applications.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Describe the primary functions and applications of common wires, cables and connectors.	Wire, Cables, and Connectors Power Distribution Signal Distribution Interconnections	2 hrs.
Describe the functions of typical fuses and breakers.	Fuses and Breakers Circuit Protection Purposes of Time Delay Low Value Resistance	2 hrs.
Describe the functions and applications of switches and relays.	Switches and Relays Circuit Interruption Distribution Control Signalling	2 hrs.
Describe the functions and applications of resistors.	Resistors Current Limiting Voltage Dropping Divide Voltage and Current Heaters	1 hr.
Describe the functions and applications of capacitors.	Capacitors Store Charge Block DC - Pass AC Pass High Frequencies Tuning Shift Phase	1 hr.
Describe the functions and applications of inductors.	Inductors Store Energy Block AC - Pass DC Pass Low Frequencies Tuning Shift Phase	1 hr.
Describe the functions and applications of transformers.	Transformers Step Voltage Up or Down Couple Isolate Match Impedances	2 hrs.

[illegible]

### SUGGESTED PROCEDURE:

1. The emphasis on this block should be directed to what each component does, that is, its function, not on how it accomplishes same or internal workings.
2. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
Irving W. Larson, ed.

- NOTES: 1. This unit may best be handled in conjunction with Block 0.14.a (Basic Electrical Parameters) intermeshed so that the student learns to measure parameters listed immediately after each is covered in turn in parameter the block or these topics may be covered as the need arises.
2. Although it is not spelled out in the outline, VOM is meant to include multimeters and further, that the meters can be either the usual analog readout types as well as digital readout types.

- REFERENCES: 1. Allied Radio Corp. Best Ways to Use Your VOM and VTVM.
2. Allied Radio Corp. Understanding and Using Your Oscilloscope.

GENERAL OBJECTIVE: The student will properly employ VOM's and VTVM's, clamp-on meters, and oscilloscopes to accurately measure voltages, currents, resistance, frequency, and common waveforms; all with the maximum precision and accuracy capabilities of each instrument.

SPECIFIC OBJECTIVES AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Describe the salient features and characteristics of the VOM, VTVM, clamp-on meters, and oscilloscope, and to select the best instrument for a given measurement.	Instrument Characteristics Capabilities of Each Accuracy Reading Scales Sensitivity Loading Effects Care of Instruments Calibration	8 hrs.
Measure with the full accuracy and precision of the instruments listed the magnitude, polarity, waveform, and frequency of any <u>voltage</u> within range of instruments listed.	Voltage Measurements VOM - DC & AC VTVM - DC & AC Clamp-on Meter - AC Oscilloscope - Any Waveform Voltage Testers - AC	15 hrs.
Measure with the full accuracy and precision of the instruments listed the magnitude, direction, frequency, and waveform of any <u>current</u> within the range of instruments listed.	Current Measurements - VOM - DC VTVM - DC Clamp-on Meters - AC Meters and Scope with Precision 1 $\Omega$ Shunt	20 hrs.
Accurately measure resistance utilizing the full precision and accuracy of available VOM and VTVM.	Resistance Measurements Continuity With VOM With VTVM	4 hrs.
Identify common waveforms with the oscilloscope and determine their frequency from measured period.	Waveform Identification Use of Oscilloscope Frequency Measurement with Oscilloscope Period (T)	5 hrs.
	$F = \frac{1}{T}$	5 hrs.

SUGGESTED PROCEDURE:

1. This basic measurements unit is facilitated nicely through the use of a lab distribution system. That is, a pair of terminals at each lab station that are all interconnected through a twisted pair. This permits each student to be measuring the same quantity at the same time.
2. Use media materials as listed in EIA - Electronics Multi-Media Handbook. Irving W. Larson, ed.

NOTES: These instruments include those that are common to the industrial electrician.

REFERENCES: 1. Available Equipment Manuals and Specifications.  
2. Instrument Manufacturer's Catalogs.

GENERAL OBJECTIVE: Select, use properly, and care for special indicators and instruments typically used in electrical occupations.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Describe the salient features and characteristics of meggers, continuity checkers, test lamps, voltage indicators, watt meters, watt-hour meters, light meters, sound level meters, temperature indicators and recording meters.	Instrument Characteristics Capabilities of Each Accuracy Reading Scales Sensitivity Care of Instruments	8 hrs.
Measure voltage levels with the instruments listed.	Voltage Measurement Test Lamp Voltage Indicators Recording Voltmeters	1 hr.
Measure with the full accuracy and precision of common meggers the magnitude of resistance.	Resistance Measurement Megger	2 hrs.
Determine the existence or non-existence of continuity with the instruments listed.	Continuity Testing Continuity Checkers Ohm-Meters Meggers	2 hrs.
Measure with full accuracy and precision of instruments listed magnitudes of power and energy.	Power and Energy Watt-Meters VOM Adapters Watt-Hour Meters	4 hrs.
Measure with full accuracy and precision of instruments listed existing ambient conditions of work areas.	Light Meters Sound Level Meters Temperature Meters Recording Meters	4 hrs.

SUGGESTED PROCEDURE:

1. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
Irving W. Larson, ed.
2. Use equipment manuals. Typical manufacturers are:  
Simpson Electric Company, Chicago, Illinois.  
Amprobe Instrument, Lynbrook, New York.  
(Meggar) James J. Biddle Company, Plymouth Meeting, Pennsylvania.
3. Use large scale mock-ups of meter faces and selector switches.

TITLE: Electric Troubleshooting I

EDUCATIONAL  
BLOCK I.20.a

NOTES: This unit should be preceded by Block I.19.a (Instruments and Measurements I) as the use of basic instruments is assumed. Further, this unit can be sequenced along with Block 0.16.

REFERENCES: Grob, Bernard. Basic Electronics.

GENERAL OBJECTIVE: Locate and identify common faults of electric components typically found in electric circuits.

SPECIFIC OBJECTIVES AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Select the proper test instrument and locate typical faults in common wires, cables and connectors.	Wires, Cables, and Connectors Opens Shorts Insulation Breakdown Resistance or Opens in Connectors	2 hrs.
Select the proper test instrument and locate typical faults in common fuses in breakers.	Fuses and Breakers	1 hr.
Select the proper test instrument and locate typical faults in switches and relays.	Switches and Relays Burned Contacts Faulty Linkages Open or Short Coils	1 hr.
Select the proper test instrument and locate typical faults in resistors.	Resistors Opens Shorts Change in Resistance Intermittants	1 hr.
Select the proper test instrument and locate typical faults in capacitors.	Capacitors Shorts Opens Leakage	1 hr.
Select the proper test instrument and locate typical faults in inductors and transformers.	Transformers and Inductors Shorts Windings Windings to Core Opens Ringing.	2 hrs.
Select the proper test instrument and locate typical faults in motors and generators.	Motors and Generators Worn Brushes Open Leads Open Windings Short Windings	2 hrs.

SUGGESTED PROCEDURE:

1. The instructor should have on hand a supply of faulty components that reflect listed faults so that the student can evaluate and trouble-shoot each.
2. Use media materials as listed in EIA - Electronics Multi-Media Handbook. Irving W. Larson, ed.

NOTES: 1. This block should be preceded by Block I.19.a and I.19.b as the use of basic instruments is assumed.

2. The tests outlined are out of circuit tests.

REFERENCES: 1. Instruction Books for Available Tube and Transistor Checkers.  
2. RCA Transistor Manual.  
3. RCA Tube Manual.

GENERAL OBJECTIVE: Locate and identify common faults of electric and electronic components typically found in electric and electronic systems and circuits.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Set the proper test instrument and locate typical faults in diodes.	Diodes Faults Heater Opens or Shorts Anode to Cathode Shorts Low Front to Back Ratio Anode-Cathode Opens Breakdown	2 hrs.
Select the proper test instrument and locate typical faults in vacuum tubes.	Vacuum Tubes Filament Open Poor Emission Low gm Element Shorts Gas Noise Microphonics Tube Testers	6 hrs.
Select the proper test instrument and locate typical faults in semiconductor devices	Semiconductors Shorts Opens Low Front to Back Ratio Low Beta Leakage Transistor Checkers Low Gain	8 hrs.
Select the proper test instrument and locate faults in sensors and transducers.	Sensors and Transducers	2 hrs.

SUGGESTED PROCEDURE:

1. The instructor should have on hand a supply of faulty components that reflect listed faults so that the student can evaluate and trouble-shoot each.
2. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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TITLE: Electrical Parameters II

BLOCK

0.14.b

NOTES: Electronic slide rule type calculation aides are available at a nominal cost from several of the major manufacturers that do a good job of relieving the student from much of the calculating type activities involved here.

REFERENCES: 1. Devito, M. Introduction to Electricity-Electronics.  
 2. Grob, Bernard. Basic Electronics.  
 3. Malvino, Albert P. Electronic Principles.  
 4. Zbar, Paul B. Basic Electricity.

GENERAL OBJECTIVE: Define and describe the electrical parameters in circuits containing capacitance and inductance, determining desired unknowns from given quantities.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Define and characterize capacitance.	Capacitance Capacitance as Ability to Store Energy in Electric Field Characteristics of Capacitance Opposition to Change in Voltage Storage of Charge Block DC Pass AC Capacitance in Series Capacitance in Parallel Unit of Capacitance ✓ Farad / Farad	10 hrs.
Determine electric parameters in circuits containing capacitance.	Symbols for Capacitance Capacitive Reactance Impedance Phase Angle Power Factor Time Constant	5 hrs.
Define and characterize inductance.	Inductance Inductance as Ability to Store Energy in Magnetic Field Characteristics of Inductance Opposition to Change in Current Block AC Pass DC Inductance in Series Inductance in Parallel Unit of Inductance Henries m Henries / Henries Symbols for Inductance	10 hrs.

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Determine electric parameters in circuits containing inductance.	Inductive Reactance Impedance Phase Angle Power Factor Time Constant	5 hrs.
Define, describe, and determine frequency in resonant circuits.	Resonance Series Resonance Parallel Resonance	4 hrs.
Characterize transformers and determine turns and impedance ratio relationships.	Transformers Power Step Up Step Down Multiple Secondary Coupling Matching Taps	4 hrs.

**SUGGESTED PROCEDURE:**

1. If the mathematics background of student group precludes the use of algebra in the solution of the following equations for desired unknowns, it is recommended that the use of nomographs such as those found in Appendix be used.

$$TC = \frac{L}{R}, \quad TC = R \times C$$

$$X_C = \frac{1}{2\pi fC}, \quad X_L = 2\pi fL, \quad Z = \sqrt{R^2 + X^2}, \quad \tan \theta = \frac{X}{R}$$

$$P.F. = \cos \theta, \quad F_r = \frac{1}{2\pi \sqrt{LC}}, \quad \frac{N_s}{N_p} = \frac{V_s}{V_p} = \frac{I_p}{I_s} = \frac{\sqrt{Z_s}}{\sqrt{Z_p}}$$

$$C \text{ eq (series)} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2}}, \quad L \text{ eq (series)} = L_1 + L_2$$

$$C \text{ eq (parallel)} = C_1 + C_2, \quad L \text{ eq (parallel)} = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2}}$$

2. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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- NOTES: 1. It should be noted that the emphasis in this block is on the function of these circuits, i.e. on the signal processing accomplished by each circuit with a complete disregard on how each circuit works internally and the circuit elements included.
2. The instructor should choose which circuits in this to treat, on the basis of which of the circuits are used in systems available for student use.
3. Total time allotment for this block should not exceed 20 hours (or 1/2 hour per circuit).

- REFERENCES: 1. Churchman, L. Survey of Electronics.
2. Sands, Leo G. Electronics Handbook for the Electrician.

GENERAL OBJECTIVE: The student will identify the primary function(s) and applications of common electronic circuits typically encountered in electronic systems.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Identify and describe the function of the listed circuits in terms of the signal processing accomplished by each unit.	Rectifiers Filters Tuned Tank Circuits Power Supplies Voltage Regulators Current Regulators Voltage Doublers Amplifiers Voltage Power Tuned Differential Voltage Followers Oscillators Multivibrators Limiters Clippers Clampers Triggers Detectors Demodulators Modulators Mixers Bridges Sync Circuits Logic Circuits And/Nand Or/Nor Flip-Flops Adders Counters Sweep Circuits Frequency Dividers AFC AVC	3-32

SUGGESTED PROCEDURE:

1. These circuits should be treated on a black-box basis. Selected circuits can be built up in boxes so that the student can relate them to a block diagram and interconnect them so as to do a sequence of signal processing to create a desired system output. If it is difficult to build up or purchase these units in quantity for student use, single units should be constructed so that they may be used for demonstration purposes.
2. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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TITLE: Electronic Troubleshooting I

EDUCATIONAL  
BLOCK 0.20.a

NOTES: This block may be covered concurrently with Block 0.18, Electronic Circuit Fundamentals and Block I.11.b, Electronic Drawings and Specifications.

REFERENCES: 1. Lemons, Wayne. Learn Electronics Through Troubleshooting.  
2. Smith, Paul C. Know Your Oscilloscope.  
3. Zbar, Paul B. Electronics Instruments and Measurements.

GENERAL OBJECTIVE: Troubleshoot electronic systems to isolate fault to circuit, functional block, or module.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Use the block diagrams and schematics as troubleshooting guides.	Total System Function Contribution of Each Circuit to Total System Function Sequence of Signal Processing Test Points Voltage Waveform	10 hrs.
Isolate fault in system to functional unit or circuit.	Identification of Symptom Total Malfunction Partial Malfunction Elimination of Functioning Units Sequential Testing Signal Injection Signal Tracing Test Point Checking Voltages Waveforms Module Substitution	10 hrs.

SUGGESTED PROCEDURE:

1. The student should be presented with faulty (bugged) electronic systems along with the block or schematic diagrams to troubleshoot, beginning with simple systems, progressing to more complex systems. The specific systems used are not listed as the techniques of troubleshooting are common to most systems. The following is given as a typical sequence:
  1. P. A. Amplifier
  2. Stereo Amplifier
  3. AM Receiver
  4. FM Receiver
  5. FM Stereo Tuner
  6. AM-FM Stereo Receiver
  7. Television B & W Receiver
2. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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TITLE: Cleaners and LubricantsBLOCK • I.25

NOTES: This is a partial listing of cleaners and lubricants used on electricity and electronics equipment.

REFERENCES: 1. G. C. Electronics Catalog, Rockford, Illinois.

GENERAL OBJECTIVE: Select and properly use different types of electrical and electronic cleaners, lubricants, and insulating materials.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Select and properly use cleaners.	Contact Cleaners (aerosol) Ethyl Alcohol Cleaning P.C. Boards	2 hrs.
Select and properly use lubricants.	Oils Silicone Lubricants	2 hrs.
Select and properly use insulating materials.	Tapes Varnish Motor Wire Insulation Transformer Wire Insulation Corona Dope High Voltage Insulation High Voltage Putty	2 hrs.
Select and properly use sealing, bonding and potting materials.	Epoxy Silicone Potting Compound	2 hrs.
Select and properly use circuit coolants.	Circuit Freeze (aerosol)	1/2 hr.

**SUGGESTED PROCEDURE:**

1. The instructor should have examples for inspection and identification.

- NOTES: 1. This block should be preceded by Block 0.20.a.
2. The instructor should select circuits to treat from list as in Block 0.18.

- REFERENCES: 1. Lemons, Wayne. Elements of Radio Servicing.
2. Lemons, Wayne. Learn Electronics Through Troubleshooting.

## GENERAL, OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Define the function of each component in typical electronic circuits.	Review of Block 0.17 (Functions of Components) Internal Operation of Typical Electronic Circuits Rectifiers Filters Differentiators/Integrators Tuned Circuits Power Supplies Regulators Voltage Doublers Amplifiers Oscillators and Multivibrators Limiters and Clippers Clampers Triggers Detectors and Demodulators Modulators Mixers Bridges Sync Circuits Logic Circuits Sweep Circuits Miscellaneous Circuits	4 hrs. 20 hrs.
Locate faulty components in electronic circuits following logical troubleshooting procedures.	Troubleshooting Isolation of Fault to Circuit or Module (Block 0.20.a) Visual Inspection Smoke Heat Voltage Measurements Current Measurements Resistance Measurements Signal Tracing Waveform Checking Tube and Transistor Checking Component Substitution Use of Freeze Sprays Use of Heat Gun Use of Cleaners	12 hrs.
Remove faulty component, secure replacement and install replacement or substitute.	Desoldering Sources of Replacement Substitute Components Soldering	4 hrs.

SUGGESTED PROCEDURES:

1. The instructor should have stock of bugged circuits for students to begin troubleshooting. Later in sequence faulty units can be solicited for student repair.
2. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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**TITLE:** Hand Tools and Hardware I

- NOTES:
1. For the electrician, some of these tools may need to be skipped such as wire wrapper, riveters, and alignment tools.
  2. This block should include sharpening and dressing of tools when applicable.
  3. Hand tools is intended to include electric and pneumatic tools as needed.

- REFERENCES: 1. Duarte, Salvador R., and Duarte, R. L. Electronics Assembly and Fabrication.  
2. Ritchie, George L. Electronics Construction Techniques.

**GENERAL OBJECTIVE:** Demonstrate proficiency with common hand tools by selecting, properly using, and caring for the tools needed in performing typical jobs.

**SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:**

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME
Properly use common hand tools in the assembly-disassembly of electronic, electrical and electro-mechanical equipment.	Screwdrivers Types Standard Blade Phillips Cross-Head S Screw Holding, etc. Nut Drivers Pliers Longnose Curved Nose Slip-Joint Gas Side Cutters Fuse and Tube Pullers Vise Grip Wrenches Box End Open End Sockets Adjustable Allen Riveters Chisels Torque Wrench Levels	8 hrs.
Properly use common hand tools in the construction and modification of electronic, electrical and electromechanical hardware systems.	Saws Hacksaw Sabre Saw Hole Saw Drills Electric Hand, Rotary Impact	8 hrs.

Hand Tools and Hardware I  
0.13.a

UPON COMPLETION OF THIS  
BLOCK, THE STUDENT WILL:

RECOMMENDED TOPICAL  
OUTLINE:

RECOMMENDED  
TIME:

Punches  
    Socket  
    Knockout  
    Center  
Hammers  
Files  
Rules and Layout Tools  
Nibblers and Snips  
Taps and Dies  
Vises  
Clamps  
Wire Stripper  
Knives  
Crimpers  
Wire Wrappers  
Screws  
    Types  
        Sheetmetal  
        Machine  
Threads  
Sizes

8 hrs.

Identify common screw sizes and types.

SUGGESTED PROCEDURE:

1. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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2. Show pictures, slides, etc. of different tools.

TITLE: Tools III (Electronic)

EDUCATIONAL

BLOCK

0.13.c

- NOTES: 1. Some of these tools may be used by the electrician.
2. The usage of these tools can best be illustrated when teaching the skills which require them.
3. Time does not include student usage.

REFERENCES: Ritchie, George L. Electronics Construction Techniques.

GENERAL OBJECTIVE: Select and use the correct electronics hand and power tools.

SPECIFIC OBJECTIVES AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Properly use common hand tools in making electrical connections.	Wire Strippers Knives Crimpers Wire Wrappers	1 hr. /
Select and use specialized tools used in electrical, electronic equipment maintenance and repair.	File Card Board Extenders Alignment Tools Gozinta Air Hoses Vacuum Cleaners Tape Head Cleaners Test Clips	2 hrs.
Identify common electronic hardware.	Grommets Standoffs Rubber Feet Terminals Terminal Strips Silicone Compounds Potting Adhesive Greases Knobs Plugs, Jacks and Binding Posts Coaxial Connectors Printed Circuit Connectors	2 hrs.

SUGGESTED PROCEDURE:

1. Use illustrations to show the physical characteristics of the tool.
2. Use the tools when demonstrating the applicable skills.
3. Use electronic parts catalogs. Typical catalogs are:  
Newark Electronics, Chicago, Illinois  
Allied Electronics, Elgin, Illinois
4. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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Soldering Skills  
0.50

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Properly apply heat, flux, and solder to form perfect solder joint.	Application of Heat to Lead Solder Flow Holding Components Heat Sinks Cooling	4 hrs.
Unsolder components from hand-wired as well as printed circuits without damage to circuit or circuit components.	Application of Heat Dangers of Over-Heating Avoidance of Splatter Techniques of Solder Removal Braid Solder Suckers Use of Soda Straw	2 hrs.
Identify special techniques of soldering encountered in electrical/electronic systems.	Grounded Tip Irons Variable Heat Irons Soldering Large Gauge Wire Solder Forms Soldering Compounds Solder Wave Baths Dip Soldering	2 hrs.     5 hrs.

SUGGESTED PROCEDURE:

1. For this block, it is recommended that the instructor obtain scrap components, PC boards, terminal strips, wires, etc., available at minimal cost as scrap from sources such as local industry, surplus outlets, etc. These can then be mounted so as to provide a wide range of typical conditions under which soldering is to be done.
2. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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TITLE: Breadboard and Prototype Construction

BLOCK

0.29

NOTES: It may be, due to cost and time considerations, that much of the sheet metal work in this block must be eliminated. It is, however, important that the student have experience in the layout, preparation, and construction of PC boards. These can be made with a minimum of equipment and materials costs.

REFERENCES: 1. Duarte, Salvador R. and Duarte, R. L. Electronics Assembly and Fabrication.  
2. Ritchie, George L. Electronics Construction Techniques.

GENERAL OBJECTIVE: Breadboard and construct prototype circuits from sketches, schematic diagrams, and blueprints, using conventional materials, techniques and components.

## SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Describe the various breadboarding systems employed by industry.	Breadboarding Systems Commercial Systems PC Boards with Pads Cardboard Vector Board	2 hrs.
Layout sheet metal chassis following conventional methods and procedures.	Chassis Types Chassis Layout Component Location Allowances for Heat Dissipation Shielding Bend Allowances	4 hrs.
Construct sheet metal chassis and mount parts following conventional techniques.	Chassis Construction and Parts Mounting Cutting Bending Spot Welding Fasteners Nibbling Riveting Hole Punching Heat Sinking Socket Mounting PC Board Mounting Techniques Vertical Horizontal Rack	10 hrs.
Wire chassis and components following standard practices.	Shock Mounting Wiring Techniques Lead Dress Terminal Strips Cable Lacing Wire Wrapping Harness Construction Flat Cable	3 hrs.

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Layout and construct printed circuit boards, using a minimum of space and following standard procedures and techniques.	Printed Circuit Techniques Types of Boards Methods of Production Taping Photographic Resist Silk Screen Layout of Circuit, Routing Etching Drilling Component Mounting	18 hrs.
Layout and construct control panels following standard methods.	Control Panel Layout	4 hrs.
Prepare a bill of materials and obtain needed parts.	Materials Sources Electronic Parts Houses	2 hrs.

**SUGGESTED PROCEDURE:**

1. If cost is a consideration in the implementation of this block, the instructor is reminded of the availability of stick-on etch resistant tape, and that cleaning and etching of boards can be done in flat cake pans. This allows for the production of PC boards at a minimum cost per unit.
2. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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NOTES: This block should be preceded by Blocks 0.29 and 0.50.

- REFERENCES: 1. Duarte, Salvador R., and Duarte, R. L. Electronics Assembly and Fabrication.  
 2. Oregon State Board of Education. Electricity-Electronics Occupational Cluster Guide.  
 3. Ritchie, George L. Electronics Construction Techniques.

GENERAL OBJECTIVE: Perform those skills necessary to properly assemble electronic equipment systems.

SPECIFIC OBJECTIVES AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Construct assemblies from pictorial diagrams or sample unit.	Printed Circuit Boards Single Sided Double Sided Baby Boards	2 hrs.
Use production line test jigs.	Jigs Types Usage	2 hrs.
Use automatic component insertion machines.	Insertion Machines Automatic Semi-Automatic	2 hrs.
Use automatic soldering machines.	Soldering Machines Automatic Semi-Automatic	2 hrs.
Prepare and lace cables.	Harness Diagrams Harness Jigs Lacing Cable	2 hrs.

SUGGESTED PROCEDURE:

1. Use pictures from catalogues or trade magazines to illustrate different machines.
2. Use surplus printed circuit boards for illustration.
3. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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TITLE: Logs and Reports

NOTES: The instructor should choose which section of this block is applicable to the occupation being covered. For example, the broadcast engineer may need only the material on F.C.C. logs.

REFERENCES: Pauley, Stephen. Technical Report Writing Today.

GENERAL OBJECTIVE: Keep clear, concise records of work performed and communicate this information to others using conventional methods and form.

## SPECIFIC OBJECTIVES AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Keep accurate records of laboratory or shop activities as performed.	Lab Notebook Dated Pages Entries Statement of Intentions Diagrams Curves, Data, Specs, Etc. Observed Data Effect of Modifications Calculations Results and Conclusions	2 hrs.
	Job Sheets Time In and Out Work Done Materials Used. Cost of Materials Rates on Time Totals	4 hrs.
Communicate technical information by writing technical reports on experiments, products, design, etc., following accepted forms.	Technical Reports Specification Sheets Process Descriptions Technical Directions and Procedures	8 hrs.
Keep complete and proper logs on equipment, making appropriate entries when necessary, including broadcast, public safety and commercial radio installations.	Log Entries FCC Rules and Regulations Form of Entries When to Make Entries Who May Make Entries Correction to Entries Filling of Logs	2 hrs.

SUGGESTED PROCEDURE:

1. Use worksheets, time cards and OSHA forms such as those included in the Appendix.
2. Use media materials as listed in EIA - Electronics Multi-Media Handbook, Irving W. Larson, ed.

NOTES: This block is intended to cover single and three phase motors and alternators.

- REFERENCES:
1. Adams, James E. Electrical Principles and Practices.
  2. Allis Chalmers. A Guide to Care of Electrical Motors.
  3. McIntyre, R. L. Electric Motor Control Fundamentals.
  4. Richter, Herbert P. Practical Electrical Wiring: Residential, Farm and Industrial.
  5. Rosenberg, Robert. Electrical Motor Repair.
  6. State of Maine Department of Education. Industrial Electricity Curriculum Manual.

GENERAL OBJECTIVE: Install, remove, connect and perform minor repairs on AC motors and alternators.

SPECIFIC OBJECTIVES AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
State the principles and sketch the circuits for the different types of AC motors and alternators.	Types of AC Machines Split Phase Motors Capacitor Polyphase Synchronous Shaded Pole Series Alternators	16 hrs.
Connect or wire single and three phase motors in accordance with blueprints or name plates..	Name Plate Data Voltage Current Wiring Diagram KVA	2 hrs.
Reverse a motor by changing the leads.	Motor Rotation Principles	1 hr.
Test a motor for shorts and grounds.	Motor Repair Tools Growler VOM	2 hrs.
Check and replace motor capacitors.	Motor Capacitors Uses Running Starting Types Oil Electrolytic Dry Voltage Rating Capacitance Rating	2 hrs.
Check and change centrifical switches.	Centrifical Switches Type Ratings	2 hrs.
Check, clean and replace brushes.	Commutator and Brushes	2 hrs.
Check bearings.	Lubrication Alignment	2 hrs.

SUGGESTED PROCEDURES:

1. Pictures of typical motors and installations would be useful.
2. Use illustrations from references #2, #3, and #4 and equipment catalogs from General Electric, Westinghouse, Emerson, Dayton and Allis Chalmers, or other typical manufacturers.
3. Assemble and disassemble an AC motor.
4. Use media materials as listed in EIA - Electronics Multi-Media Handbook. Irving W. Larson, ed.

TITLE: Motor Repair and Overhaul

BLOCK

I.23.

- NOTES: 1. The scope of this block is all rotating devices up to 100 h.p. or as handling capabilities will allow, i.e., machines requiring special handling equipment should not be covered.
2. This block can be done in conjunction with Block I.12 and I.13.

- REFERENCES: 1. Adams, James E. Electrical Principles and Practices.
2. A Guide to the Care of Electrical Motors.
3. Anderson, Edwin P. Electric Motor Guide.
4. Lytel, Allan H. ABC's of Electric Motors and Generators.
5. Mages, Loren J. Electric Generating Systems.
6. Rosenberg, Robert. Electric Motor Repair.
7. Schweitzer. Fractional Horsepower Motors and Repair.
8. Smeaton, Robert. Motor Application and Maintenance Handbook.

GENERAL OBJECTIVE: Overhaul, rebuild and repair rotating electrical devices.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Check, lubricate and/or replace bearings.	Bearings Roll Sleeve Ball Rotor Shafts End Plates Lubricants Oils Greases Method of Applying Oil or Grease	2 hrs.
Replace Brushes.	Brushes Function Motors That Use Brushes Grades Sizes Shades Material	2 hrs.
Replace or adjust centrifugal switches.	Centrifugal Switches Function Motors That Use Switches Sizes Types Ratings Location	2 hrs.
Rewind stator, rotor and field windings.	See Reference #6, Electric Motor Repair	8 hrs.
Test pole piece polarities.	Pole Piece Polarities Function Types of Tests	1 hr.
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Motor Repair and Overhaul  
I.23

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Balance rotors and reassemble motor with proper end loading or end play.	Bearings End Plates	4 hrs.
Test windings, components and connections for shorts, grounds and opens.	Visual Inspection Resistance Readings Test Points Ohms Intermittant	2 hrs.
Replace defective parts such as wire, capacitors, connectors and cables.	Wire Types Coils Insulation Mounting Capacitors Type Oil Electrolytic Function	4 hrs.
Repair and adjust small motors.	Small Motors Types Vibrating Printed Circuit Stepping Universal	4 hrs.
Use motor test equipment and tools listed in the outline.	Growler Internal External Test Light Coil Winders Compass Undercutter	4 hrs.

SUGGESTED PROCEDURE:

1. Obtain and use faulty motors for the students to practice their troubleshooting techniques.
2. Use motors to demonstrate repairing and lubricating techniques.
3. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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ACKNOWLEDGEMENTS:

Doran Hershberger, General Electric, DeKalb, Illinois.

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1. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
-Irving W. Larson, ed.

TITLE: Audio Systems

BLOCK

0.22

NOTES: Time as recommended herein does not include practical experience as outlined in the suggested procedure.

REFERENCES: 1. Brown, Lewis Hacleroad. AV Instruction: Media and Methods.  
2. Nisbett, Alec. The Technique of the Sound Studio for Radio, Television and Film.

GENERAL OBJECTIVE: Install, operate and maintain theatre (live) audio systems.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Install audio systems in and on public rooms, auditoriums and stages.	Audio Systems Fixed Portable Components Speakers Microphones Amplifiers Patch Panels Tape Recorders Audio Cable Control Location for: Speakers Microphones Location	24 hrs.
Place microphones and speakers to avoid acoustic problems and to produce special audio effects.	Acoustics Cross Coupling Feedback Dead Spots Mixing	4 hrs.
Install audio system per specifications and in accordance with applicable codes.	Installation Location Portable Fixed Patch Panel Function Wiring Diagram Codes Electrical Wiring	6 hrs.
Match impedances of cable and components.	Impedance Matching Purpose Function Pads	1 hr.
Operate stage and auditorium audio systems in accordance with script, manager and action cues. Assist in planning and producing recording sessions for stage and music production.	Control Room Layout Control Panel Master Mixers Patch Panel Recorders Sound Cues Script Stage Manager Action	10 hrs.       2 hrs.

**SUGGESTED PROCEDURE:**

1. Have the student work with or for student sponsored theatre groups. Again it should be emphasized that the student must have an appreciation for the theatre and an understanding of stage plays.
2. Practical or hands-on experience is not included herein but would be gained by working on a school production.
3. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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TITLE: Instruments and Measurements III

EDUCATIONAL  
BLOCK 0.19.a

NOTES: Instruments and Measurements (I.19.a) is a prerequisite to this block. The topics covered in this block might best be covered as needed rather than as a block in itself.

REFERENCES: 1. Manufacturer's Instruction Manuals  
2. Training and Retraining, Inc. Understanding and Using Test Instruments.

GENERAL OBJECTIVE: Select, use properly, and care for instruments and test equipment used in troubleshooting electronic systems.

SPECIFIC OBJECTIVES AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Describe the salient features and characteristics of signal generators (both AF & RF), signal tracers, capacitor checkers, transistor testers, logic probes and test jigs and fixtures.	Instrument Characteristics Capabilities of Each Accuracy Reading Scales Sensitivity Care of Instruments Calibration	4 hrs.
Apply and trace a signal through an electronic system with the equipment listed.	Signal Generators Audio Frequency Radio Frequency Sweep Generators	2 hrs.
Determine the condition of transistors, vacuum tubes, and integrated circuits found in electronic systems.	Transistor Testers Tube Testers IC Checkers Logic Probes	2 hrs.
Identify bad or leaky capacitors, inductors, and determine their value with maximum accuracy.	Capacitor Checkers Bridges	1 hr.
Properly use special test jigs and fixtures in evaluating electronic system components.	Test Jigs and Fixtures Extender Boards Special Extender Cables Soldering Fixtures	1 hr.

SUGGESTED PROCEDURE:

1. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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2. Use equipment manuals. Typical manufacturers are:  
Henlett Packard, Palo Alto, California.  
Tektronix, Beaverton, Oregon.  
Sencore Inc., Sioux Falls, South Dakota.

NOTES: See troubleshooting guides in Appendix for techniques.

- REFERENCES: 1. Grob, Bernard and Kiver, Milton. Applications of Electronics.  
 2. Lemons, Wayne. Transistor Radio Servicing Course.  
 3. Shrader, Robert. Electronic Communications.  
 4. Zbar, Paul B. Basic Radio: Theory and Servicing.

GENERAL OBJECTIVE: Operate, troubleshoot and align radio receivers, including AM and FM broadcast as well as communications equipment.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Demonstrate his knowledge of radio receivers by constructing block diagrams of typical types showing the signal processing performed by each block.	AM Receivers R.F. Amplifiers Tuning Circuits Converters (Mixers) I.F. Amplifiers Detectors Grid Leak Plate Diode Regenerative Amplifiers A.V.C. FM Receivers R.F. Amplifiers Tuning Circuits Converters I.F. Amplifiers Discriminators Ratio Detector Phase Slope Detection Tuning Indicators A.F.C. FM Stereo (Multiplex) S.C.A. (Store Cast) Pre-Emphasis De-Emphasis Audio Amps	20 hrs.
Tune and align AM, FM, FM-Stereo and communications receivers following standard procedures.	Signal Injection Order of Tuning Adjusting AGC	5 hrs.
Tune receivers to antennas.	Antenna Types Tuning Mobile Receivers Transceivers C.B. Units	1 hr.
Troubleshoot and align miniature receivers.		5 hrs.

**SUGGESTED PROCEDURE:**

1. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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TITLE: Instruments and Measurements IV

NOTES: Prerequisite to this block are Blocks I.19.a, and O.19.a.

- REFERENCES:
1. Lemons, Wayne. Transistor Radio Servicing Course.
  2. Manufacturer's Instruction Manuals.
  3. Shrader, Robert L. Electronic Communication.
  4. Zbar, Paul B. Basic Radio: Theory and Servicing.

GENERAL OBJECTIVE: Select, use properly and care for specialized instruments used in checking, aligning, and troubleshooting radio frequency electronic systems.

## SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Describe the salient features and characteristics of frequency counters, grid-dip meters, RF power meters, RF sweep generators, distortion analyzers, dummy loads, special test and calibration equipment and test jigs and fixtures.	Instrument Characteristics Capabilities of Each Accuracy Scales and Dials Loading Effects Sensitivity Care of Instruments Calibration	6 hrs.
Measure frequency of RF signals with the full accuracy and precision of the instruments listed.	Grid Dip Meters Frequency Counters Oscilloscope	3 hrs.
Measure RF power levels and SWR with the full accuracy and precision of the instruments listed.	RF Power Meters Watt Meters	1 hr.
Analyze RF Waveforms.	Distortion Analyzer	1 hr.
Align and troubleshoot RF systems by signal injection techniques.	RF Signal Generator Sweep Generators	2 hrs.
Properly use dummy loads, and special equipment in aligning and troubleshooting RF equipment.	Dummy Loads Special Test Equipment (as applies to specialized equipment) Special Calibration Equipment Test Jigs and Fixtures	4 hrs.

**SUGGESTED PROCEDURES:**

1. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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2. Demonstrate different measuring techniques.

TITLE: Alignment and Calibration

NOTES: This block covers electronic meters and test equipment as well as TV and radio receivers. Also included is TV convergence.

- REFERENCES: 1. Equipment Manufacturer's Manuals and Instruction Books.  
 2. Lemons, Wayne. Transistor Radio Servicing Course.  
 3. Tinnell, Richard W. TV Symptom Diagnosis, An Entry into TV Service.  
 4. Zbar, Paul B. Basic Radio: Theory and Servicing.

GENERAL OBJECTIVE: Be able to calibrate and align electronic test equipment and radio and TV receivers.

## SPECIFIC OBJECTIVES AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Test, align, and calibrate electronics test equipment using manufacturer's drawings and specifications and known frequency and voltage standards.	Test Equipment Oscilloscope VTVM VOM Counters Signal Generators	4 hrs.
Align receivers using a sweep generator and oscilloscope.	Radio Receivers AM FM FM-Stereo FM Stereo Multiplexer Television B & W Color CB	2 hrs.
Converge a color television set using a color bar/dot generator.	Short Wave Color TV Convergence Hi Voltage Adjust Purity Static Convergence Gray Scale Dynamic Convergence	2 hrs.

**SUGGESTED PROCEDURE:**

1. Use manufacturer's data for alignment and calibration.
2. Use existing lab test equipment to demonstrate calibration.
3. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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**SUGGESTED PROCEDURE:**

1. Use media materials as listed in EIA - Electronics Multi-Media Handbook,  
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TITLE: R. F. Systems II (Transmitters)

EDUCATIONAL

BLOCK

0.27.b

NOTES: A First Class FCC License is required to sign the station log.

REFERENCES: Chicago Board of Education. Curriculum Guide for Occupational Electronics.

GENERAL OBJECTIVE: Operate, tune, and troubleshoot radio frequency transmission equipment in accordance with accepted procedures as outlined by the federal communications rules and regulations.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Demonstrate his knowledge of transmitters by constructing block diagrams of typical types showing signal processing performed by each block.	AM Transmitters Power Supplies Amplifiers Oscillators Buffers Power Amplifiers Modulators and Modulation Theory High Level Low Level Drivers and Exciters Emission Classifications	30 hrs.
	FM Transmitters Power Supplies Amplifiers Oscillators Frequency Multipliers Buffers Power Amplifiers Modulators Direct (FM) Phase Modulators Pulse Modulation Keying System Emission Classifications	30 hrs.
Tune, operate, and troubleshoot transmitters.	Tolerances (F.C.C.) Frequency Power Modulation Tuning of Transmitters Neutralization F.C.C. Operating Rules Techniques of Troubleshooting Reading and Logging of Meters and Monitors	15 hrs.

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Describe the characteristics and applications of common transmission lines.	Transmission Lines Types Impedance Matching VSWR VSWR Meters Time Domain Reflectometers	8 hrs.
Describe the characteristics and applications of common antenna systems.	Antenna Systems Single Directional Impedance Patterns Gain Amplifiers Tuning Couplers Splinters Baluns Traps Alternators Taps	20 hrs.

SUGGESTED PROCEDURE:

1. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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- NOTES: 1. There are many excellent study guides, Q & A manuals and texts for use in preparing for the license in addition to the study materials available from area FCC engineering offices at a nominal cost.
2. Second and first class is probably beyond the high school level.

- REFERENCES: 1. Kaufman, Milton. Radio Operators License Q & A Manual.
2. Shrader, Robert. Electronic Communications.

GENERAL OBJECTIVE: Demonstrate knowledge of FCC rules and regulations as well as knowledge of radiotelephone systems by passing the FCC First Class Test.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Pass Third Class FCC Commercial Radiotelephone License Test.	Element I Basic Law	
	Element II Basic Operating Practice	
Pass Second Class FCC Commercial Radiotelephone License Test.	Element III Basic Radiotelephone and Troubleshooting DC Circuit Elements and Theory AC Theory Inductance and Transformers Capacitors AC Circuits Resonance and Filters Electron Tubes Solid State Devices Motors and Generators AC Power Supplies Meters and Scopes Oscillators and Multi-vibrators H.F. Amplifiers R.F. Amplifiers Transmitters, AM and FM Receivers, AM and FM Antennas and Transmission Lines Frequency Measurement Microwave	
Pass First Class FCC Commercial Radiotelephone License Test.	Rules and Regulations Element IV Advanced Radiotelephone Television Broadcast - Commercial Rules and Regulations	60 hrs.

SUGGESTED PROCEDURE:

1. This unit should serve as a capstone to a sequence in radio electronics to be offered in the senior year of high school if at all.
2. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
<p>Calibrate and Troubleshoot: Perform a leak test with a liquid; Clean, assemble, calibrate and test instrumentation equipment as stated in the outline.</p>	<p>Tape Recorders Circular Recorders Control Systems Open Loop Close Loop Analog Digital Automatic Semi-Automatic Synchos</p>	8 hrs.
	<p>Basic Equipment Pneumatic and Electric Relays Selector Valves Positioners Recorders and Indicators Including Transmitters and Receivers Level Controllers Pressure Switches Solenoid Valves Pressure Gauges Dial Thermometers Control Drives and Linkage Control Valve Diaphragms Transducers Computer Hardware Conductivity Cells Ph Cells Flowmeters Pressure and Temperature Indicator CO<sub>2</sub> and Oxygen Recorders Level Indicators Level Recorders Pressure and Temperature Recorders Manometers Electronic Tubes Portable Vibrometers Integrators Gas and/or Oil Firing Pressure Regulators Weightometers Vacuum Recorders and Indicators Timers and Clocks Meters Alarms and Annunciators as Applies to Section Combustion Controls</p>	16 hrs.

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
	Three Element Lead Controls Superheat and De-superheat Controls Level Controls on Heaters, Sumps, Tanks, Etc. Water Treatment Controls Damper Controls Pump Controls Pulverizer Controls Hydrogen Controls Coal Feeder Controls Temperature Controls Fan Speed Controls Feed Water Controls	

SUGGESTED PROCEDURE:

1. Many of these skills can be illustrated using refrigeration, air-conditioning and heating controls from old or wreck units.
2. Tour to local industries.
3. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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NOTES: Time permits little practical application and many of these skills could be considered in the job training.

- REFERENCES: 1. Manas, Vincent. National Plumbing Code Handbook.  
 2. Matthias, A. J., and Smith, Estes. How to Design and Install Plumbing.  
 3. Oravetz, Jules, Sr. Plumbers and Pipe Fitters Library.

GENERAL OBJECTIVE: Install and connect electrical/electronic equipment that require water and waste disposal connections as well as fuel supplies

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Define common terms used in plumbing and identify common plumbing system components.	Terms and Definitions	2 hrs.
Install and modify waste disposal systems.	Drainage and Waste Sizes and Types Materials Traps Ventillation Installation Modification	4 hrs.
Install and modify hot and cold water supplies.	Water Supply Sizes Materials Iron Copper Plastic Installation Modification Fixtures Valves	4 hrs.
Install and connect equipment to gas and other fuel supplies.	Gas Connection and Fittings Fuel Oil Connection and Fittings	4 hrs.

**SUGGESTED PROCEDURE:**

1. Visit appliance repair shops.
2. Time will probably not allow for practical application and emphasis should be on demonstration.
3. Show pictures, slides etc. of typical installations.

TITLE: Install and Read Recording Instruments

EDUCATIONAL

BLOCK° I.31

NOTES: This block is intended for electric utility workers and instrument technician. The instructor must decide which areas are to be covered.

- REFERENCES: 1. Howard Sams Technical Staff, ed. Instrumentation Training Course.  
 2. Ohio Trade and Industrial Education Service. Electric Lineman.  
 3. USOE. Construction Occupations Curriculum Project.

GENERAL OBJECTIVE: Install, connect and read time recordings of voltage, current, power and other electrical parameters.

SPECIFIC OBJECTIVES AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Connect magnetic tape recording meters to single and three phase circuits.	Magnetic Recorders	4 hrs.
Set up and operate magnetic tape recording meters.	Power Input	
Load and unload magnetic tape recording meters.	Input Connections	
	Tape	
	Reels	
	Drive Mechanism	
	Speed Setting	
Connect chart recording meters to single and three phase circuits.	Chart Recorders	2 hrs.
	Circular	
	Power Input	
	Input Connections	
Set up and operate chart recording meters.	Charts	2 hrs.
	Types	
	Layout	
Load and unload charts.	Speed Setting	1 hr.
Connect recorders to measure voltage or current.		2 hrs.

SUGGESTED PROCEDURE:

1. Demonstrate recorder connection, set up, and calibration.
2. Obtain catalogs from recorder manufacturers. Typical manufacturers are: Bell and Howell Co., Pasadena, California; Ampex, Redwood City, California; and Teletype Corp., Skokie, Illinois.
3. Visit a laboratory or control room for some industrial process such as electric utility, water utility, chemical laboratory, etc.
4. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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ACKNOWLEDGEMENTS:

Robert Billing, Illinois Public Service Co., Champaign, Illinois.

NOTES: 1. Because of the preponderance of specialized terminology, abbreviations and acronyms in the electrical field, they should be pointed out and emphasized throughout the educational sequence.

2. This block is designed to include architectural drawings.

- REFERENCES: 1. Graham, Kennard C. National Electrical Code and Blueprint Reading.  
 2. Heine, Gilbert M. How to Read Electrical Blueprints.  
 3. Sundberg, Elmer W. Building Trades Blueprint Reading, Part I.  
 4. The Wiring Diagram--How to Read It--Interpret It--Use It. (Cassette Tape).

GENERAL OBJECTIVE: Read and interpret conventional drawings, schematics, blueprints and specifications encountered in electrical occupations.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Identify and describe conventional types of drawings, schematics, diagrams, graphs and charts encountered in electrical occupations.	Types of Drawings Block Diagrams Schematics Wiring Diagrams One-line Diagrams Three-line Diagrams Sketches System Map (Utilities) Pictorials Control Drawings Blueprints Architectural House Wiring Signal Wiring Motor and Generator Blueprints Graphs and Charts Bar and Pie Charts Volt-Ampere Graphs Characteristic Curves Nomographs	8 hrs.
Read and interpret standard electrical terminology, abbreviations and acronyms.	Glossary of Electrical Terms	1 hr.
Read and use standard electrical symbols and industrial variations.	Symbols Electrical Mechanical Architectural	4 hrs.

Drawings and Specifications (Electrical)  
I.11.a

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Read and interpret conventional drawings, diagrams and charts used in electrical occupations.	Conventions of Electrical Drawings Lines Lettering Title Blocks Notes Date and Revisions (change letter) Bill of Materials Model and Serial Number Block Diagrams Schematics One-line Drawings Three-line Drawings System Maps Production Drawings Control Drawings Architectural Drawings	1 hr.
4. Identify and describe standard types of specifications used in the electrical industry.	Specifications Types of Specifications Operating Performance Contractual Architectural Cost Test Installation	1 hr.
Read and interpret conventional specifications for electrical equipment.	Specifications Content Input Current Voltage Power Ripple Frequency Output Voltage Current Power Frequency Stability Accuracy Environmental Temperature Vibration Humidity Shock	4 hrs.
Draw sketches of electrical units, using conventional practices.	Mounting Specifications Sketching	2 hrs.
Read, use and follow manufacturer's assembly and operating instruc-	Manufacturer's Data Operating Manual Shipping Manual Assembly Instructions	2 hrs.

Drawings and Specifications (Electrical)  
I.11.a

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Operate a polaroid camera.	Polaroid Camers Configuration Operation	1 hr.
Locate replacement parts using supply house catalogs.	Supplier Catalogs Typical Examples	1 hr.

SUGGESTED PROCEDURE:

1. The instructor should have a wide assortment of different types of drawings, diagrams, specification sheets and blueprints so that the students get experience in reading as many of the types as possible.
2. The student should also obtain a complete glossary, dictionary of electrical terminology and a diagram of typical electrical symbols used in electrical diagrams. See appendix.
3. Use media materials as listed in EIA - Electronics Multi-Media Handbook. Irving W. Larson, ed.

- NOTES: 1. This block should be taught both as a separate block and as an integral part of others as needed.
2. This block is organized around the national code and applicable variance as indicated by state and local codes should be included.

- REFERENCES: 1. National Electrical Code.
2. Watt, John H. NFPA Handbook of the National Electrical Code.

GENERAL OBJECTIVE: Plan electrical circuits, purchase parts, and install electrical circuits and equipment in accordance with national, state, and local codes.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Define terminology used in codes properly.	Terminology of Codes (Article 100)	10 hrs.
Locate codes applicable to job to be done.	Code Organization and Structure (Article 110)	10 hrs.
Determine electrical codes and select proper breaker, wire, and service equipment and parts according to National Code Articles 200-280.	Wiring Design and Protection Use of Conductors Branch Circuits Feeders Services Overcurrent Protection Grounding Lighting Protection	40 hrs.
Select proper wiring methods for job according to National Code Articles 300-390.	Wiring Materials and Methods Temporary Wiring Conductors for General Wiring Continuous Rigid Cable Supports Open Wiring Sheathed Cables Entrance Cables Underground Cables Extensions Conduit and Tubing Raceways Wire Ways Flat Cable Bus and Cable Ways Boxes and Fittings Switches	30 hrs.
Wire equipment for general use according to National Electrical Code Articles 400-480.	Equipment for General Use Flexible Cords and Cables Flexible Wires Lighting Equipment	20 hrs.

UPON COMPLETION OF THIS  
BLOCK, THE STUDENT WILL:

RECOMMENDED TOPICAL  
OUTLINE:

RECOMMENDED  
TIME:

Wire special occupancies and special equipment under special conditions according to National Electrical Code Articles 500-555, 600-680, 700-750, and 800-820.

Appliances  
Electrical Heating  
De-Icing and Snow Melting  
Motors, Motor Circuits and  
Controllers  
Air Conditioning and  
Refrigeration  
Generators  
Transformers  
Capacitors  
Resistors and Reactors  
Storage Batteries

Special Occupancies  
Hazardous Locations  
Commercial Garages  
Residential Garages  
Hangers  
Service Stations  
Health Care Facilities  
Theaters, etc.  
Mobile and Recreational  
Vehicle Facilities  
Marinas

Special Equipment  
Signs and Lighting  
Cranes and Hoists  
Elevators and Escalators  
Welders  
Recording Equipment  
Data Processing Systems  
Organs  
X-Ray Equipment  
Industrial Tools

Special Conditions  
Emergency Systems  
Over 600 Volts  
Low Voltage (Under 50V)  
Remote and Signal Circuits  
Outside Circuits  
Stand-by Systems

Communications Systems  
Communication Circuits  
Radio and TV Equipment  
CATV

15 hrs.

10 hrs.

10 hrs.

10 hrs.

#### SUGGESTED PROCEDURE:

1. Have students look up specifications for jobs in code book.
2. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
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NOTES: Wiring I covers rough wiring for non-metallic sheathed cable (Romex), armored cable and flexible conduit. Interior Wiring II will cover rigid and thin wall conduit.

- REFERENCES:
1. Adams, James E. Electrical Principles and Practices.
  2. Alerich, Walter N. Electrical Construction Wiring.
  3. Croft, Terrill, et. al. American Electricians Handbook.
  4. Graham, Kennard C. Interior Wiring - Residential.
  5. Marcus, Abraham. Electricity for Technicians.
  6. Mileaf, Harry. Electricity One-Seven.
  7. Richter, Herbert P. Practical Electrical Wiring: Residential, Farm and Industrial.
  8. Richter, Herbert P. Wiring Simplified.
  9. Sears Roebuck Company. Simplified Electrical Handbook.
  10. USOE. Construction Occupations Curriculum Project.

GENERAL OBJECTIVE: Select and install common wiring systems.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Install wiring boxes in or on floors, walls and surfaces.	Wiring Boxes Outlet Utility Sectional Switch Floor Pull Boxes Box Accessories Covers Extension Rings Surfaces (Interior and Exterior) Masonry 2 x 4 Studs Plaster Sheet Roll Wood Siding Aluminum Siding Steel Siding Vinyl Siding Installation Hardware Staples Pipe Straps Toggle Bolts Beam Straps Wall Board Hangers Ground Rods Ground Clamps Hickeys	8 hrs.       8 hrs.  8 hrs.           8 hrs.

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Install a mast type or underground service entrance in or on surfaces as listed in the outline including meter box, ground rod and distribution panel.	Entrance Service Conduit Grounding Meter Box Entrance Panel Overhead Specification Clearance, etc.	6 hrs.
Install non-metallic sheathed cable from entrance panel to outlet box.	Non-Metallic Sheathed Cable Types (NM and NMC) Two Wire Three Wire Ground Wire Ampacity and Voltage Rating	20 hrs.
Install greenfield (Flexible Conduit) from outlet box to electrical load.	Flexible Steel Conduit Types AC and MC Two Wire Three Wire Ground Wire Ampacity and Voltage Rating	2 hrs.
Install low voltage wiring and components.	Low Voltage Systems * Furnace Antenna Systems Intercom Door Bell	5 hrs.
Install armored cable from outlet box to electrical load.	Metal Clad Cable Types AC and MC Two Wire Three Wire Ground Wire Ampacity and Voltage Rating	2 hrs.

#### SUGGESTED PROCEDURE:

1. See Reference #10 for detailed steps.
2. Construct a 8 foot 2 x 4 wall and install service entrance, circuit breaker panel and outlets.
3. Use electrical equipment manufacturer's catalogs.
4. In conjunction with building construction, the class could wire a house. This would require additional time.
5. Use media materials as listed in EIA - Electronics Multi-Media Handbook. Irving W. Larson, ed.

NOTES: -1. There are special tools required of the electrician which are not covered in Block 0.13.a.

2. Actual tool usage can be covered with the blocks as the skill is being presented.

3. Time does not include tool usage

REFERENCES: The Bending System, Republic Steel Corporation.

GENERAL OBJECTIVE: Select and use the correct electrical tools.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Select and use hand and power tools for installing conduit.	Rigid Conduit Power and Hand Benders Hand and Power Reamers Vise Hand and Power Threaders Thin Wall Hand Benders Reamers Crimpers Saws Hacksaw (Hand) Hacksaw (Power) Hole Saw Impact Wrench Pipe Cutter	12 hrs.

**SUGGESTED PROCEDURE:**

1. Use illustrations to show the student the physical characteristics of the tools.
2. Use the tools when demonstrating the skills of Blocks I.13.b.
3. Use material on conduit tools from Benfield Bender Co. and Rigid Tool Co. or other typical conduit tool companies.
4. Use media materials as listed in EIA - Electronics Multi-Media Handbook. Irving W. Larson, ed.

NOTES: 1. Wiring II covers thin wall and rigid conduit. Other wiring systems (open wiring, metal raceways, under floor raceways, bus duct, etc.) are not covered.

2. Conduit usage in this block is limited to two inch.

- REFERENCES:
1. Bending the Bendfield Way.
  2. Croft, Terrill, et. al. American Electricians Handbook.
  3. Marcus, Abraham. Electricity for Technicians.
  4. Mileaf, Harry. Electricity One-Seven.
  5. Richter, Herbert P. Practical Electrical Wiring: Residential, Farm and Industrial.
  6. Richter, Herbert P. Wiring Simplified.
  7. USOE. Construction Occupations Curriculum Project.

GENERAL OBJECTIVE: Install common wiring systems including materials and devices.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Use a knockout punch for cutting holes in wiring boxes.	Wiring Boxes Outlet Utility Sectional Etc.	1 hr.
Mount electrical equipment cabinets, panels and boxes on various type surfaces as listed in the outline.	Electrical Equipment Cabinets Meter Cabinets Disconnect Cabinets Disconnect Switches Distribution Panel Starter Switches Branch Circuit Panel	12 hrs.
Mount and wire electrical controls.	Electrical Controls Float Switches Thermostats Pressure Switches	3 hrs.
Install surface metal raceway.	Surface Metal Raceway Types One Piece Two Piece Pancake Sizes Capacity Codes Fittings Wall Clips Elbows Switches Receptacles	2 hrs.
Cut rigid and thin wall conduit using hand and power cutters.	Conduit (Thin Wall and Rigid) Standard Lengths Standard Diameters Capacity	1 hr.

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Ream rigid conduit.	See Block 0.13.b	5 hrs.
Thread rigid conduit using hand or power threaders.	See Block 0.13.b	2 hrs.
Bend kicks, saddle and 90° bends in rigid conduit using power threaders.	See Block 0.13.b	6 hrs.
Bend kicks, saddle and 90° bends in thin wall conduit using hand threaders.	See Block 0.13.b	6 hrs.
Install conduit wiring boxes and panels in or on floors, walls and various type surfaces as listed in the outline.	Conduit Hardware Couplings Connectors Reducers Off Sets Conduit Toggle Bolts Pipe Straps Concrete Inserts Conduit Hangers Bushings Locknuts Explosion Proof	15 hrs.
Install wire in conduit.	Wire Solid Stranded Wire Material Sizes Ampacity Insulation	15 hrs.
Know and identify waterproof wiring systems.	Fixtures Hardware	

**SUGGESTED PROCEDURE:**

1. Reference Number 7 is a most complete reference available and is of sufficient detail to be very helpful.
2. Use media materials as listed in EIA - Electronics Multi-Media Handbook. Irving W. Larson, ed.

TITLE: Rewire and Modify

- NOTES: 1. This block would include single and three phase.
2. This block should be sequenced closely with Blocks I.13.a and I.13.b.

REFERENCES: Richter, Herbert P. Practical Electrical Wiring: Residential, Farm and Industrial.

GENERAL OBJECTIVE: Install in existing buildings in accordance with applicable code, new electric circuits and equipment.

SPECIFIC OBJECTIVES AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Identify location and path of new circuit.	Conduit Ducts Crawl Space Attic Hidden or Visible Surface Metal Raceway	2 hrs.
Identify method of installation.	Estimate Load Existing New	1 hr.
Identify need for increasing size of the service.	Electrical Load Size Distance	2 hrs.
Identify new circuit breaker or fuse requirements. Identify new circuit capacity and wire size.	Connection Points Entrance Panel Junction Boxes	2 hrs.
Identify new circuit connection point.	Tool and Devices Hanger Strips Surface Wire and Outlets Outlet Boxes with Compression Straps	4 hrs.
Identify and know the function of special tools and devices used for rewiring.	Extension Drills Wiring Behind Baseboards Wiring in Lath and Plaster Wiring in Wallboard Wiring in Two Story Structures Surface Wiring Installing Additional Circuits Installing Expanded Service Panel	6 hrs.
Identify and know the function of special rewiring techniques.		

SUGGESTED PROCEDURE:

1. Using existing electrical plans have the student layout and size new circuits.
2. Use electrical devices and manufacturer's catalogs. Typical manufacturers are:
  - Hubbell Wiring Devices, Bridgeport, Connecticut
  - All-Steel Equipment, Aurora, Illinois
  - Rawlplug Co., New Rochelle, New York
  - General Electric, Providence, Rhode Island
3. Use media materials as listed in EIA - Electronics Multi-Media Handbook.  
Irving W. Larson, ed.

TITLE: Customer Relations/Job Orientation

EDUCATIONAL

BLOCK 0.80

NOTES: Materials covered on this topic should be included as an on-going part of any program, as well as contained within this block of specific instruction.

- REFERENCES:
1. Chapman, Elwood N., Your Attitude is Showing, (Science Research Associates: Chicago, Illinois), 1972.
  2. Dubin, Robert, The World of Work; Industrial Society and Human Relations, (Prentice-Hall: Englewood Cliffs, New Jersey), 1958.
  3. Personal Development for Young Men, 1st ed., (Instructional Materials Laboratory, Distributive Education Department, Division of Extension, University of Texas: Austin, Texas), 1967.

GENERAL OBJECTIVE: To identify the major components of interpersonal relations in a work situation.

SPECIFIC OBJECTIVE AND TOPICAL OUTLINE:

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Identify the major components of a work situation	Responsibilities of his specific job Overall structure of responsibility in the organization Structure of authority in the organization	1 hour
Identify informal components of a work situation	Informal groups Cliques Persons with shared technical interests Voluntary work groups Persons with shared backgrounds and education	1 hour
Identify the components of being a member of an organization	Goals of the organiza- tion Organization's role & function in the community Individual's position- within the organiza- tion Necessary work contacts Immediate supervisor Co-workers Technical advisers Persons requiring supervision	1 hour

UPON COMPLETION OF THIS BLOCK, THE STUDENT WILL:	RECOMMENDED TOPICAL OUTLINE:	RECOMMENDED TIME:
Identify appropriate work habits	Anticipated relationships with persons outside of the organization Technical advisers Sources of parts & equipment Customers Timeliness	1 hour
Identify components of sound personal skills and behavior	Neat appearance Pleasant demeanor Strong business vocabulary Descriptive words Effective speaking Pronunciation Voice tone Sincerity Poise Clarity Good personality over the phone Answering the phone Taking messages Transferring calls Giving information Speaking clearly, audibly Closing the phone conversation Good manners Positive attitude Cooperative point of view	2 hours

#### SUGGESTED PROCEDURE:



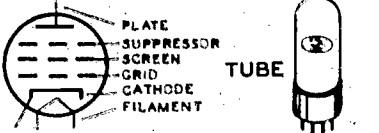
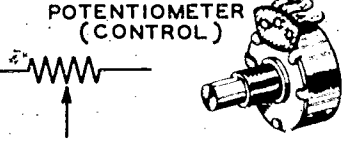
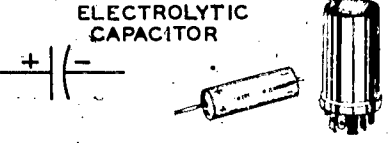

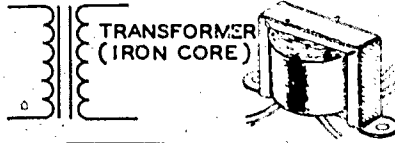
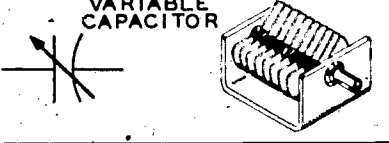
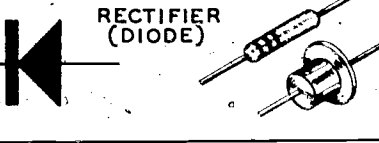
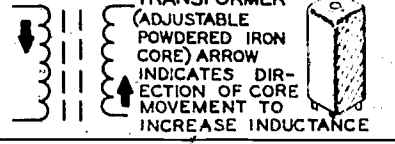
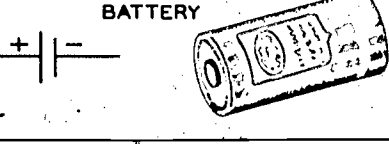
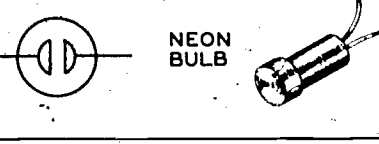
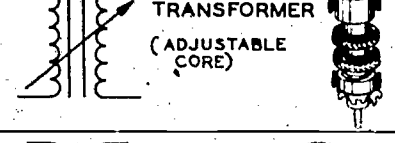
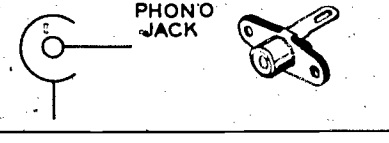
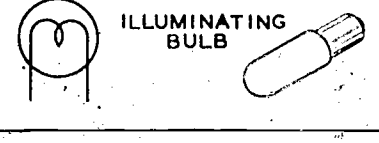
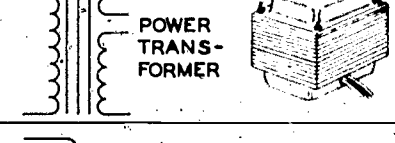
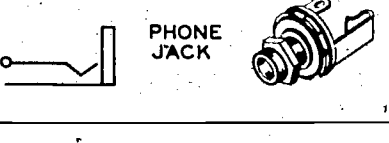
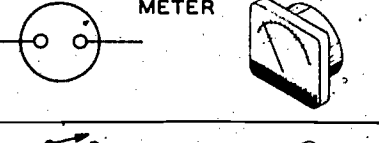
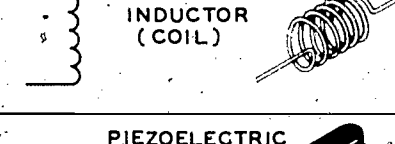
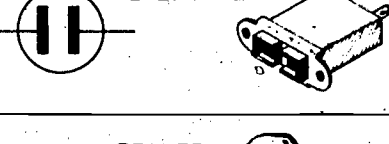
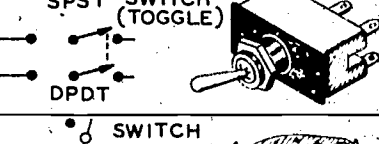
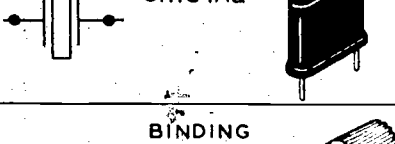

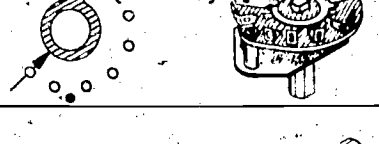
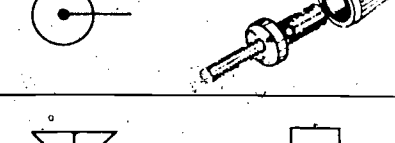
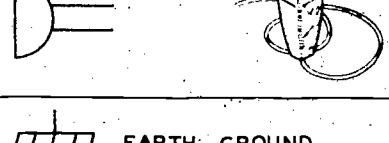
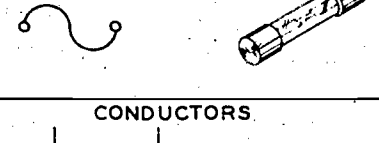

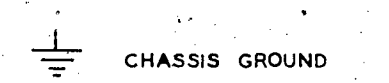

1. Provide the student with as much input from real-life work situations as possible: for example, arrange for visits by student groups to local businesses; bring past graduates of the school back to classroom to discuss the problems they encountered as new employees; provide talks by industrial representatives (e.g., personnel managers), from local businesses and industry on the qualities that they like to see in an employee.

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# TYPICAL COMPONENT TYPES

This chart is a guide to commonly used types of electronic components. The symbols and related illustrations

should prove helpful in identifying most parts and reading the schematic diagrams.

 <p>RESISTOR</p>	 <p>CAPACITOR</p>	 <p>PLATE SUPPRESSOR SCREEN GRID CATHODE FILAMENT TUBE</p>
 <p>POTENTIOMETER (CONTROL)</p>	 <p>ELECTROLYTIC CAPACITOR</p>	 <p>PNP COLLECTOR BASE EMITTER NPN COLLECTOR BASE EMITTER</p>
 <p>TRANSFORMER (IRON CORE)</p>	 <p>VARIABLE CAPACITOR</p>	 <p>RECTIFIER (DIODE)</p>
 <p>TRANSFORMER (ADJUSTABLE POWDERED IRON CORE) ARROW INDICATES DIR- ECTION OF CORE MOVEMENT TO INCREASE INDUCTANCE</p>	 <p>BATTERY</p>	 <p>NEON BULB</p>
 <p>TRANSFORMER (ADJUSTABLE CORE)</p>	 <p>PHONO JACK</p>	 <p>ILLUMINATING BULB</p>
 <p>POWER TRANS- FORMER</p>	 <p>PHONE JACK</p>	 <p>METER</p>
 <p>INDUCTOR (COIL)</p>	 <p>RECEPTACLE</p>	 <p>SPST SWITCH (TOGGLE) DPDT</p>
 <p>PIEZOELECTRIC CRYSTAL</p>	 <p>SPEAKER</p>	 <p>SWITCH (ROTARY)</p>
 <p>BINDING POST</p>	 <p>MICROPHONE</p>	 <p>FUSE</p>
 <p>ANTENNA GENERAL LOOP</p>	 <p>EARTH GROUND CHASSIS GROUND</p>	 <p>CONDUCTORS NOT CONNECTED CONNECTED SHIELDED</p>

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## GUIDE FOR READING AND DRAWING SCHEMATIC DIAGRAMS

### A SCHEMATIC DIAGRAM:

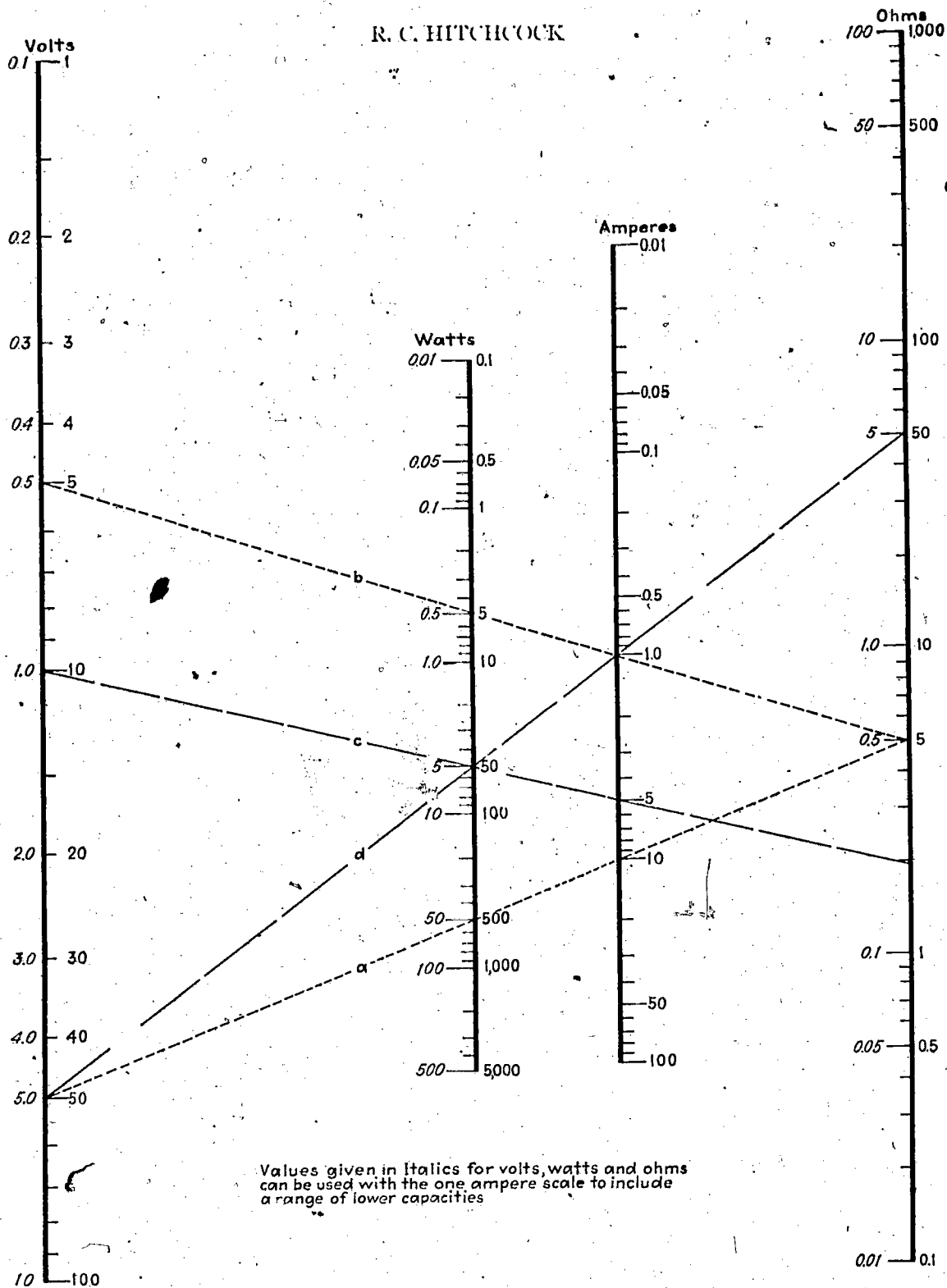
1. shows the sequence of signal operations.
2. shows the dependence of each circuit block on neighboring blocks.
3. provides a pattern for troubleshooting the system.
4. provides a method for locating the parts on the chassis.
5. shows mechanical connections, linkages, or grouping of components.
6. shows external connections.
7. shows relative importance of components.
8. shows interconnection of components.
9. tells values and limitations of the components.

### RULES TO FOLLOW WHEN READING OR DRAWING SCHEMATICS:

1. Signal flows from left to right.
2. Signal components (coupling) are generally connected horizontally.
3. Power flows up or down.
4. Power components are generally connected vertically.
5. All lines are drawn either horizontally or vertically, unless specifically required by the symmetry of the circuit.
6. Ground is always at the bottom.
7. All test points, components, connections, pin locations, etc., are labeled.
8. Overall symmetry must be upheld through:
  - a. evenly spaced components
  - b. similar components are placed at same level on the schematic
  - c. parallel construction
  - d. progressive construction
9. Standard symbols and conventions are used.
10. Function and importance of components and circuits are indicated through components placement and orientation.

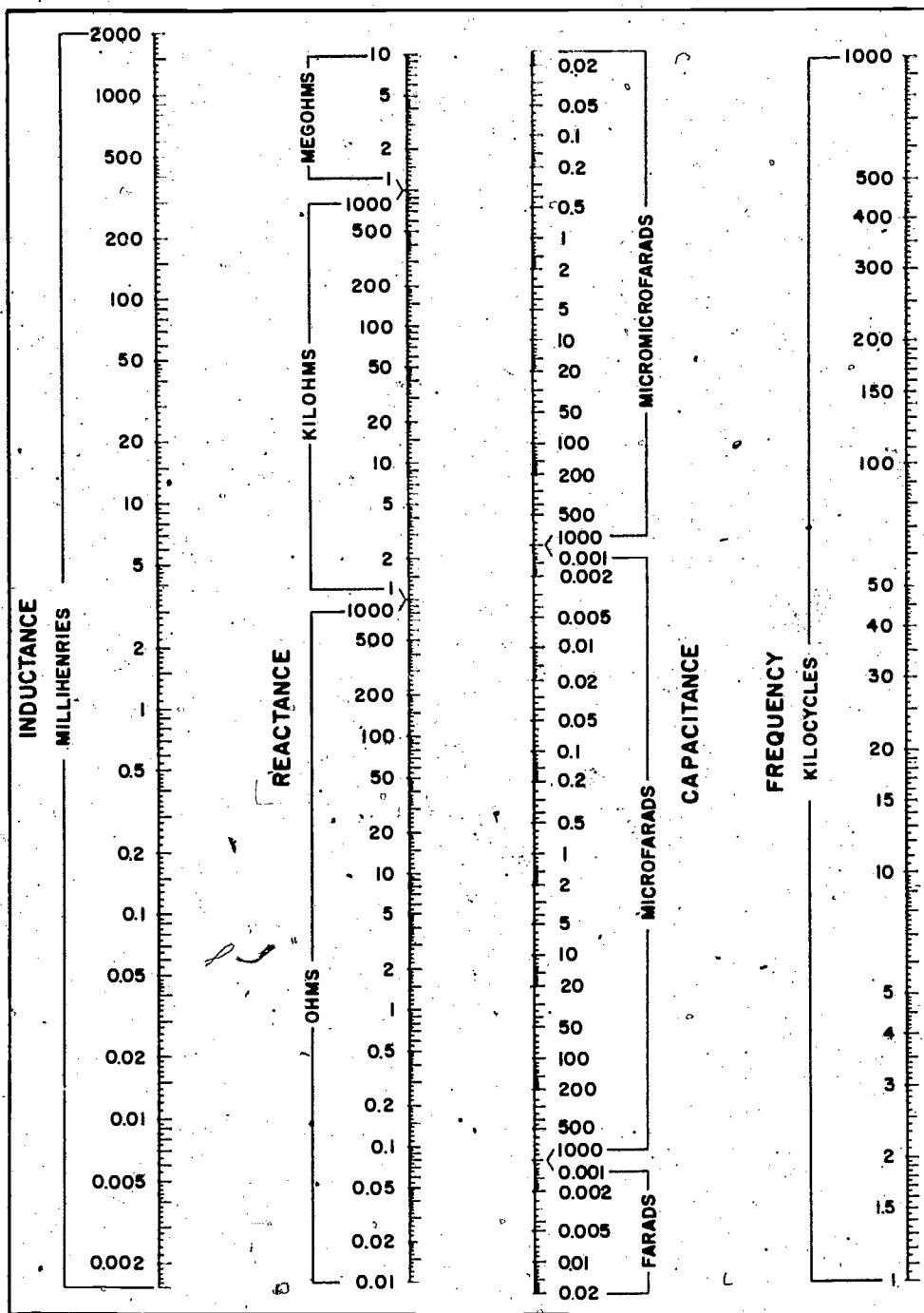
# Chart for Solving Ohm's Equations

R. C. HITCHCOCK

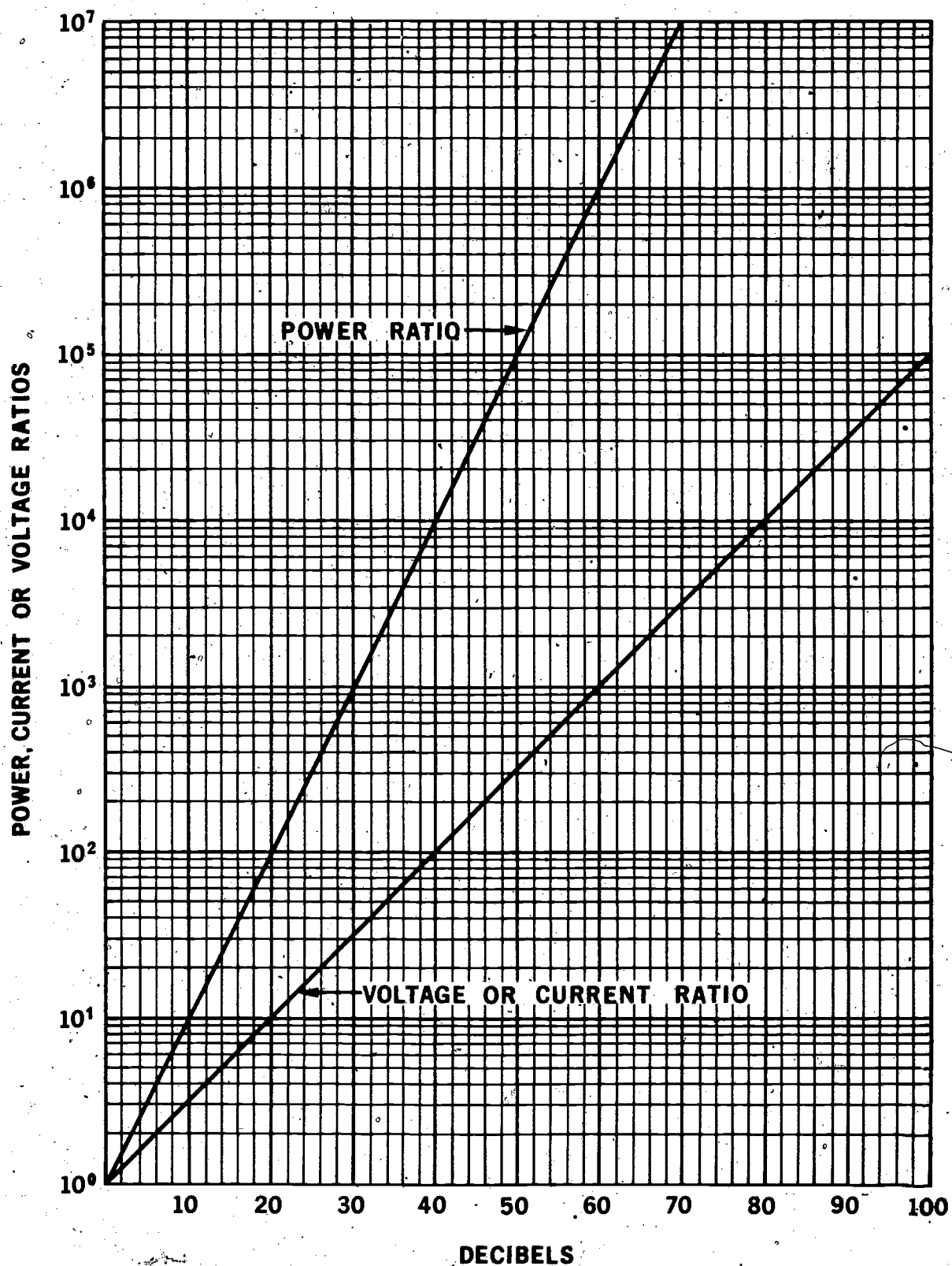


# FREQUENCY-REACTANCE-CAPACITANCE-

## INDUCTANCE CHART (Cont)



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SAMPLE WORK ORDER FORMS

Provided by Larry Mielcarz  
Kankakee Area Career Center  
Kankakee, Illinois 60901

OCCUPATIONAL SAFETY AND HEALTH ACT NOTES

Area or Equipment Inspected \_\_\_\_\_

Inspected by \_\_\_\_\_ Date \_\_\_\_\_

INSPECTION COMMENTS:

RE-INSPECTION REPORT

Area or Equipment Inspected \_\_\_\_\_

Inspected by \_\_\_\_\_ Date \_\_\_\_\_

INSPECTION COMMENTS:

REQUESTED BY			
ADDRESS			
CITY			
CUSTOMER ORDER NO.	LOCATION	SERVICEMAN	DATE OF ORDER

MAINTENANCE ORDER

KACC ELECTRIC SERVICE

1st Call Date	serviceman	
J.T.	J.T.	J.T.


2nd Call Date	serviceman	
J.T.	J.T.	J.T.


Date	Signature

Material

Time

Date

Material

Time

Date

Material

Time

Date

Material

Time

Date

Material

Time

Date

Material Total

**DATE:**

[illegible]

[illegible]

### WHAT YOU NEED TO KNOW TO TROUBLESHOOT!

Developed by Ernest Hopkins, Electronics Instructor  
Parkland College, Champaign, Illinois

When an individual is beginning to learn how to troubleshoot, he may tend to go off in many different directions at once and become frustrated at not being able to solve electronic servicing problems except by a hit or miss process. To avoid this random guessing approach, the beginner needs guidance and direction in what he should know to troubleshoot effectively and efficiently. He needs to know how to proceed with his investigation once he has started. Many beginners look at a complicated piece of electronic equipment that contains 20 tubes or transistors, 200 or more capacitors and resistors, numerous transformers and diodes, and are awed and confused as what to do next. At this point many individuals are turned off by electronics because they feel they will never be able to work on anything that is so complicated. This author knows the feeling!

"You must crawl before you can walk" is an apt cliché at this point. By this it is meant that the individual should not tackle a complicated electronic system until he has mastered the circuits and he should not troubleshoot the circuits until he has a thorough knowledge of the components involved. He must also understand the relationship of the components to each other in the circuit and the relationships of the circuits to each other in the system.

There are some (including the author) that might say "This is all fine and good but I want to know where I'm supposed to go and how do I know when I get there in learning to troubleshoot?" The following is a general guide to troubleshooting that will aid the beginner in answering these questions and hopefully help to keep him on the right track when he starts to stray or become frustrated. This is meant to be an overview of troubleshooting in general and a guide to "how to proceed" with a complex system once the material

in this text has been mastered. In learning how to troubleshoot from the beginning, the material in the following chapters will be covered in an inverted order to this list. That is, the components will be covered first then the circuits that are made up of these components and then systems that are made up of these circuits.

### A GENERAL GUIDE TO TROUBLESHOOTING: QUESTIONS AND EXPLANATION

The following is a general and practical guide to troubleshooting most problems that will occur in an electronic system. It may appear as though much of this information is common sense, but "common sense" is not very common anymore. The steps are arranged in what can be considered a logical sequence. The questions asked, are the questions that should be asked at that step in the troubleshooting so as to proceed in an orderly fashion and avoid chaos. The suggestions made are based on the premise that the problem or problems need to be solved by the simplest and most expedient method.

#### A General Guide to Troubleshooting: Questions

##### Step I. Learn the function of the system!

1. What does the system do?
2. How does the system perform its function?
3. How are the circuits of the system interrelated to perform the overall function of the system?

##### Step II. Identify the symptom!

1. What does the system not do that it should?
2. What does the system do that it should do?
3. Are there any symptoms that can be detected by the senses (smell, touch, sight, hearing)?
4. Have you seen the symptom before?

##### Step III. Isolate the problem area!

1. What areas can cause the symptom?
2. What areas do not affect the symptom?
3. Can a quick visual inspection detect the problem area?
4. What measurement or test will aid in locating the problem area?
5. What test equipment will be required?
6. Have you had this problem before?

Step IV. Stop and think!

1. Is everything very confusing at this point?
2. Should you clear your mind of any preconceived ideas?
3. Should you start over?
4. Are you jumping around from one area to another without following a logical pattern or a logical sequence of events?

Step V. Isolate the problem to a specific area!

1. What is the function of the area?
2. How does it perform its function?
3. Will a close visual inspection detect the problem?
4. What measurement or test will aid in locating the problem the quickest?
5. What test equipment will be required?
6. What is the function of each component in the area?
7. What can be bad about each component?
8. How can the component be checked?
9. What caused the component to become defective?
10. If an exact replacement component is not available is there a suitable substitute?
11. Does replacing or repairing the defect solve the problem?
12. Will the unit continue to operate to acceptable standards?

(Following is a more detailed version of the outline)

Step I. Learn the functions of the system!

1. What does the system do?
  - A. A radio receiver converts electromagnetic energy at high frequencies into audio frequencies that can be detected by the ear.
  - B. The television receiver converts electromagnetic energy at high frequencies into audio frequencies to which the ear can respond and to light impulses to which the eye can respond.
  - C. The tape recorder converts intelligence that has been stored on magnetic tape into audio energy to which our ears can respond and the system must move the tape mechanically so as provide continuous intelligence.
2. How does the system perform its function?
  - A. Amplifiers are used to increase the amplitude of signals.
  - B. Oscillators must be used to generate a constant signal within the system.
  - C. Mixers are sometimes used to combine signals.

- D. Detectors are used to separate signals.
  - E. Waveshaping circuits are used to change or modify existing waveforms into a more useable form.
  - F. Transducers are used to convert one form of energy into another form. Voltage to accoustical energy.
  - G. Motors are used to cause mechanical movement.
  - H. Adjustments and controls are placed within the system to allow for tolerance interface between components and for component aging.
3. How are the circuits for the system interrelated to perform the overall function of the system?
- A. Some stages depend on an input from a previous state and then send the output on to following stages. In other cases the output from a stage is sent back to previous stages for purposes of controlling the previous stages.

Step II. Identify the symptom!

1. What does the system not do that it should?
  - A. The system is completely dead and no performance can be detected.
  - B. The system is producing a noise but no intelligence.
  - C. The system has no or improper mechanical movement.
  - D. The system produces aural intelligence but no visual intelligence.
  - E. The system produces a visual but no aural intelligence.
  - F. The system produces all functions required but not to an acceptable standard.
  - G. The system produces functions that are at an acceptable standard but intermittently.
2. What does the system do that it should?
  - A. Many times by noting what the system does do, the stages that perform these functions correctly can be ignored. This is important because the more complex the system the more you can ignore when those stages are performing correctly.
3. Are there any symptoms that can be detected by the senses? (sight, hearing, smell, touch)
  - A. Perform a visual inspection of the system to locate any broken wires, burned or broken parts, signs of smoke, broken or cracked printed circuit boards, loose connections and hardware, and burned out vacuum tubes.

- B. Listen for any strange noise such as arcing, howling, frying, and shattering.
  - C. Use the nose to detect any strange odors that indicate over-heated components such as resistors and transformers.
  - D. Touch the cases of transistors, transformers, electrolytic capacitors, and resistors for any unusually high temperatures. (Be careful of large transformers, resistors and some power transistors; these do have rather warm cases.)
4. Have you seen the symptom before?
- A. Learn to categorize and relate various combinations of symptoms. This will aid in the future troubleshooting of similar systems and in turn reduce the time required for identifying all the symptoms and will enable you to better relate the symptoms to the problem.

**Step III. Isolate the problem to a general area!**

1. What areas can cause the symptom?
  - A. If the system is completely dead and a visual inspection indicates that the filament are not lit, then the only area that can cause this situation is the low voltage power supply.
  - B. If the turntable of a phonograph is not rotating, then this problem can be associated with either the power supply or the mechanical section of the system. This problem will not normally be associated with a defective amplifier unless of course the amplifier is overloading the power supply and causing it to become inoperative.
  - C. If the signal that is processed through the system is weak, then this would be an indication that there is lack of amplification and therefore checking the amplifiers would be a logical step to perform.
2. What areas do not affect the symptom?
  - A. If a television receiver has a good picture but poor or no sound signal, then only those stages that contain the sound signal need be checked and the stages that do not incorporate the sound signal can be ignored. Therefore in the more complicated systems, it is easier to locate the problem area by noting which of the areas of the system are functioning normally.

3. Can a quick visual inspection detect the problem area?

A. In this case, the whole system is being visually checked and in the more complex systems, such as a color television, anything but a quick inspection (2 to 5 minutes) would involve a loss of time in troubleshooting. For example, an open capacitor or transistor cannot be spotted visually, but a broken wire, or burned out filament or a blown fuse is quick and easy to detect.

4. What measurement or test will aid in locating the problem area?

A. The test or measurement to be made will depend somewhat on the system, the symptom, and test equipment available. In one case the signal injection method might be best, while in another case, signal tracing might be best suited for isolating the problem.

5. What test equipment will be required?

A. It must be decided on the basis of what the symptom is and what equipment is available. The frequency and amplitude of a piece of test equipment must be taken into consideration for some applications. Some systems such as television may require special types of signals to apply to it in order to aid in troubleshooting. For some troubleshooting problems, it is best to have a visual output indicator rather than an aural indication. This would be especially true where waveforms are of prime importance as related to function performed.

6. Have you had this problem before?

A. Many times previous experience with problems can help in guiding the troubleshooter to a likely trouble area because he has had the same type of problem before, especially if it is the same model or chassis that he has worked on before. Some particular models seem to have a weakness in one particular part of the system due to its design.

#### Step IV. Stop and think!

1. Is everything very confusing at this point?

A. There are times in every technician's life when he tends to run around in circles and a solution to the problem evades him. This can be caused by having missed anyone of the steps above or having avoided a logical sequence of events up to this point. Sometimes a review of data collected, symptoms present, or measurements made will allow the technician to progress.

## 2. Should you clear your mind of preconceived ideas?

- A. Sometimes previous experience has taught us that a particular symptom is caused by a certain defect; but when that area is checked, it is found to be in good order. Once this has been determined leave that area alone. Too many times the technician is so convinced that the problem is in this area that he wastes time by continually returning to this area because he has a preconceived idea about the solution.

## 3. Should you start over?

- A. Interruptions and taking up troubleshooting where someone else left off or using data someone else has collected can lead a technician down the wrong path of analysis. In this case, it is best to start over.

## 4. Are you jumping around from one area to another without following a logical pattern or a logical sequence of events?

- A. This can be caused by either of items 1 and 2 above in this step or just one of those nervous and jumpy days that we all get.

Step V. Isolate the problem to a specific area!

## 1. What is the function of the specific area?

- A. Is it an amplifier, an oscillator, a power supply, or a signal splitter. Knowing the function will help in deciding what is not being performed properly.

## 2. How does it perform its function?

- A. Knowing how the area goes about performing its function will help to isolate which of the components in the area could cause such a problem. It will also alert the technician as to what to look for when making measurements and collecting data.

3. Will a close visual inspection detect the problem?

- A. At this point in isolating the problem, the technician only has a few components and a small area for concern. It may be a good idea to take a few minutes and closely inspect such items as cracked boards and components that might have been missed by the quick inspection.

## 4. What test equipment will be required?

- A. The test equipment required at this level may be different than it was when the problem was being isolated down to a general area. Here voltage measurements may be of great importance because this is what is reflected in the tech data.

Sometimes current measurements are given in the data; but to make such measurements, the circuit path must be broken and this is not always convenient to do. Therefore, a voltage measurement across a known resistance will yield the same information by simple computation.

5. What test equipment will be required?

A. The loading effect of the test equipment may dictate which equipment is to be used. As to whether measurements can be made with power on or off may be another important factor.

6. What is the function of each component in the area?

A. By knowing the component's function, it can be determined as to whether that particular component's being bad can cause the problem in that area.

7. What can be bad about each component?

A. Shorted, open, leaky, increased or decreased value are various symptoms that a component can exhibit. Knowing the defect that a component can have, can alert the technician to what to look for in checking out that component.

8. How can the component be checked?

A. A diode and sometimes a coil or transformer can be simply checked with an ohmmeter but it must usually be disconnected from the rest of the circuit. A capacitor can be checked sometimes with an ohmmeter (if it is 1 ufd or larger) but at other times it is best to use a capacitance checker if one is available. There is always the direct replacement method which is usually the best method if you don't wipe out the replacement in the process.

9. What caused the component to become defective?

A. Many times a bad transistor may be found in a circuit and it is replaced with a new one, but a short time later it too becomes defective. This gets to be expensive. Therefore, when a component becomes defective, it may have done it on its own or another component's having become defective took the transistor or components with it. It is a good idea, in this case, to check the other components associated with the defective one.

10. If an exact replacement component is not available, is there a suitable substitute?

A. The use of part substitution manuals can reduce the down time on defective equipment. (It would be

terrible to have to send to Hong Kong or Tokyo for a transistor!) There are special cases where suitable substitutes will not work very well. Tubes are an example of this problem. Current requirements of the filament may be different and this would be fine in a parallel filament arrangement but not so good for a series strung set.

11. Does replacing or repairing the defect solve the problem?

A. It could be that your analysis of the suspected part was wrong and it really wasn't bad and the problem still exists. There might be more than one problem.

12. Will the unit continue to operate to acceptable standards?

A. Some repairs will correct the defect but the quality has decreased. This might be due to the interface of the new component to the older ones in the systems and alignment is called for. The poor quality could be caused by a suitable substitute being used that is not so suitable.

B. Continued performance of the repaired unit is often neglected; because once a defective component is replaced, it is assumed that the problem is solved. Reviewing item 9 above, we find that maybe something caused the component replaced to become defective and until that something is corrected the unit cannot be considered to be totally repaired. The repaired unit should be operated under normal conditions for a period of time after the repair has been made.

The preceding outline and guide to troubleshooting is only meant to let the beginning troubleshooter know what he is in for when servicing electronic systems and circuits. As each of the succeeding chapters is covered, the individual should return to this outline/guide and review the appropriate area to see how the material covered fits into the overall logic of troubleshooting.

## Glossary

**ABRASIVE:** A material that cuts material that is softer than itself, such as emery, aluminum oxide and diamonds. It may be used in loose form, mounted on cloth, paper or bonded on a wheel.

**ABSOLUTE SYSTEM:** A system of numerically controlled machining that measures all coordinates from a fixed point of origin or zero point. Also known as point-to-point N/C machining.

**ACCUMULATOR:** A container in which fluid is stored under pressure as a source of fluid power.

**ACTUATOR:** A device for converting hydraulic energy into mechanical energy. A motor or cylinder.

**ADDENDUM:** The radial distance between the pitch circle and the top of the tooth.

**ALCLAD:** An aluminum alloy core with a thin coating of pure aluminum to prevent corrosion of the core metal.

**ALLOWANCE:** The intentional difference in the dimensions of mating parts to provide for different classes of fits.

**ALLOY:** A mixture of two or more metals fused or melted together to form a new metal.

**ANNEAL:** To soften metals by heating to remove internal stresses caused by rolling and forging.

**ANODIZE:** The process of protecting aluminum by oxidizing in an acid bath using a d-c current.

**ARBOR:** A shaft or spindle for holding cutting tools.

**ASSEMBLY DRAWING:** A drawing showing the working relationship of the various parts of a machine or structure as they fit together.

**BACKLASH:** The play (lost motion) between moving parts, such as threaded shaft and nut or the teeth of meshing gears.

**BASIC DIMENSION:** A theoretically exact value used to describe the size, shape or location of a feature.

**BASIC SIZE:** That size from which the limits of size are derived by the application of allowances and tolerances.

**BEND ALLOWANCE:** The amount of sheet metal required to make a bend over a specific radius.

**BLANCHARDIZE:** An operation which removes large amounts of stock through rotary grinding. Normally, it is a first operation for preparing castings for finish operations.

**BLANKING:** A stamping operation in which a press uses a die to cut blanks from flat sheets or strips of metal.

**BORING:** Enlarging a hole to a specified dimension by use of a boring bar. May be done on a lathe, jig bore, boring machine or mill.

**BOSS:** A small local thickening of the body of a casting or forging to allow more

## Glossary of Terms

thickness for a bearing area or to support threads.

**BRAZE:** To join two close fitting metal parts with heat and a filler material of zinc and copper alloy.

**BROACH:** A tool for removing metal by pulling or pushing it across the work. The most common use is producing irregular hole shapes such as squares, hexagons, ovals or splines.

**BURNISH:** To smooth or polish metal by rolling or sliding tool over surface under pressure.

**BURR:** The ragged edge or ridge left on metal after a cutting operation.

**BUSHING:** A metal lining which acts as a bearing between rotating parts such as a shaft and pulley. Also used on jigs to guide cutting tool.

**CALLOUT:** A note on the blueprint giving a dimension, specification or a machine process.

**CAM:** A rotating or sliding device used to convert rotary motion into intermittent or reciprocating motion.

**CARBURIZE:** The heating of low-carbon steel for a period of time to a temperature below its melting point in carbonaceous solids, liquids or gases, then cooling slowly in preparation for heat treating.

**CASE HARDENING:** The process of hardening ferrous alloy so that the surface layer or case is made much harder than the interior core.

**CASTING:** An object made by pouring molten metal in a mold.

**CHECK VALVE:** A valve which permits flow of fluid in one direction only.

**CHOKE:** A restriction, the length of which is large with respect to its cross-sectional dimension.

**CIRCUIT:** The complete path of flow in a hydraulic system including the flow-generating device.

**CIRCUIT DIAGRAM:** A line drawing using alphic symbols or pictorial views to

show the complete path of flow in a hydraulic system.

**CIRCULAR PITCH:** The length of the arc along the pitch circle between the center of one gear tooth to the center of the next.

**CLOSED LOOP:** A system in which the output of one or more elements is compared to some other signal to provide an actuating signal to control the output of the loop.

**COMMAND SIGNAL (or input signal):** An external signal to which the servo must respond.

**COMPONENT:** A single unit or part.

**CONCENTRIC:** Having a common center as circles or diameters.

**CONTOUR:** The outline of an object.

**CONTROL:** A device used to regulate the function of a unit.

**COOLER:** A heat exchanger used to remove heat from the hydraulic fluid.

**COUNTERBORE:** The enlargement of the end of a hole to a specified diameter and depth.

**COUNTERSINK:** The chamfered end of a hole to receive a flat head screw.

**DASH NUMBER:** A number preceded by a dash after the drawing number that indicates right- or left-hand parts as well as neutral parts and/or detail and assembly drawings. The coding is usually special to a particular industry.

**DATUM:** A point, line, surface or plane assumed to be exact for purposes of computation from which the location of other features are established.

**DEDENDUM:** The radial distance between the pitch circle and the bottom of the tooth.

**DESIGN SIZE:** The size of a feature after an allowance for clearance has been applied and tolerances have been assigned.

**DETAIL DRAWING:** A drawing of a single part that provides all the information necessary in the production of that part.

**DIE:** A tool used to cut external threads by hand or machine. Also a tool used to

impart a desired shape to a piece of metal.

**DIE-CASTING:** A method of casting metal under pressure by injecting into metal dies of a die-casting machine. Also the part formed by die-casting.

**DIE STAMPING:** A piece cut out by a die.

**DISPLACEMENT:** The quantity of fluid which can pass through a pump, motor or cylinder in a single revolution or stroke.

**DOWEL PIN:** A pin which fits into a hole in an abutting piece to prevent motion or slipping, or to ensure accurate location of assembly.

**DRAFT:** The angle or taper on a pattern or casting that permits easy removal from the mold or forming die.

**ECCENTRIC:** Not having a common center. A device that converts rotary motion into reciprocating (back and forth) motion.

**EFFECTIVITY:** The serial number(s) of an aircraft, machine, assembly or part on which a drawing change applies. The change may be indicated as an effective date and would apply on that date forward.

**ENCLOSURE:** A rectangle drawn around a component or components to indicate the limits of an assembly. Port connections are shown on the enclosure line.

**EXTRUSION:** Metal which has been shaped by forcing it in the hot or cold state through dies of the desired shape.

**FEATURE:** A portion of a part, such as a diameter, hole, keyway or flat surface.

**FEEDBACK (or feedback signal):** The output signal from a feedback element.

**FERROUS:** Metals that have iron as their base material.

**FILLET:** A concave intersection between two surfaces to strengthen the area.

**FILTER:** A device whose primary function is the retention by a porous media of insoluble contaminants from a fluid.

**FINISH:** General finish requirements such as paint, chemical or electroplating rather than surface texture or roughness. (See surface texture.)

**FIT:** The clearance or interference between two mating parts.

**FIXTURE:** A device used to position and hold a part in a machine tool. It does not guide the cutting tool.

**FLANGE:** An edge or collar fixed at an angle to the main part or web as an I-beam.

**FLAT PATTERN:** A layout showing true dimensions of a part before bending. May be actual size pattern on polyester film for shop use.

**FLUID:**

1. A liquid or gas.
2. A liquid that is specially compounded for use as a power-transmitting medium in a hydraulic system.

**FLUIDICS:** A contraction of the words "fluid" and "logic," fluidics is a technology concerned with logical control functions and makes use of low pressure fluid interaction to produce control signals. Fluidic devices have no moving parts.

**FORGING:** Metal shaped under pressure with or without heat.

**FORM TOLERANCING:** Permitted variation of a feature from the perfect form indicated on the drawing.

**FUSION WELD:** The intimate mixing of molten metals.

**GEOMETRIC DIMENSIONING AND TOLERANCING:** A means of dimensioning and tolerancing a drawing with respect to the actual function or relationship of part features which can be most economically produced. It includes positional and form dimensioning and tolerancing.

**GUSSET:** A small plate used in reinforcing assemblies.

**HARDNESS TEST:** Techniques used to measure the degree of hardness of heat-treated materials.

**HEAT EXCHANGER:** A device which transfers heat through a conducting wall from one fluid to another.

**HEAT TREATMENT:** The application of

## Glossary of Terms

heat to metals to produce desired qualities of hardness, toughness and/or softness. (See anneal.)

**HOBGING:** A special gear cutting process. The gear blank and hob rotate together as in mesh during the cutting operation.

**HONE:** A method of finishing a hole or other surface to a precise tolerance by using a spring loaded abrasive block and rotary motion.

**HORSEPOWER (HP):** The power required to lift 550 pounds one foot in one second or 33,000 pounds one foot in one minute. A horsepower is equal to 746 watts or to 42.4 British thermal units per minute.

**HYDRAULIC CONTROL:** Control which is actuated by hydraulically induced forces.

**HYDRAULICS:** Engineering science pertaining to liquid pressure and flow.

**INCREMENTAL SYSTEM:** A system of numerically controlled machining that always refers to the preceding point when making the next movement. Also known as continuous path or contouring method of N/C machining.

**INDICATOR:** A precision measuring instrument for checking the trueness of work.

**INTERCHANGEABILITY:** The condition that assures the universal exchange or mutual substitution of units or parts of a mechanism or an assembly.

**INVOLUTE:** A spiral curve generated by a point on a chord as it unwinds from a circle or a polygon.

**JIG:** A device used to hold a part to be machined and positions and guides the cutting tool.

**JOGGLE:** A bend in a part to fit over other parts.

**KERF:** The slit or channel left by a saw or other cutting tool.

**KEY:** A small piece of metal (usually a pin or bar) used to prevent rotation of a gear or pulley on a shaft.

**KNURL:** The process of marking the surface of a part by rolling depressions in

the surface.

**LAP:** To finish a surface with a very fine abrasive impregnated in a soft metal.

**LIMITS:** The extreme permissible dimensions of a part resulting from the application of a tolerance.

**MAGNAFLUX:** A nondestructive inspection technique that makes use of a magnetic field and magnetic particles to locate internal flaws in ferrous metal parts.

**MAXIMUM MATERIAL CONDITION:** When a feature contains the maximum amount of material, that is: minimum hole diameter and maximum shaft diameter. Abbreviated MMC.

**MILL:** To remove metal with a rotating cutting tool on a milling machine.

**MISMATCH:** The variance between depths of machine cuts on a given surface.

**NEXT ASSEMBLY:** The next object or machine on which the part or sub-assembly is to be used.

**NOMINAL SIZE:** A general classification term used to designate size of a commercial product.

**NONFERROUS:** Metals not derived from an iron base or an iron alloy base, such as aluminum, magnesium and copper.

**NORMALIZING:** A process in which ferrous alloys are heated and then cooled in still air to room temperatures to restore the uniform grain structure free of strains caused by cold working or welding.

**ORTHOGRAPHIC PROJECTION:** A multi-view drawing that shows every feature of an object in its true size and shape.

**PASSIVATION:** Particularly applicable to stainless steel, it is a conditioning of the surface with a low strength nitric acid dip that develops the "stainless" property and prevents random staining due to "free iron" particles left from machining.

**PICKLE:** The removal of stains and oxide scales from parts by immersion in an acid solution.

**PILOT:** A protruding diameter on the end

of a cutting tool designed to fit in a hole and guide the cutter in machining the area around the hole.

**PILOT HOLE:** A small hole used to guide a cutting tool for making a larger hole.

Also used to guide drill of larger size.

**PILOT VALVE:** An auxiliary valve used to control the operation of another valve.

The controlling stage of a 2-stage valve.

**PINION:** The smaller of two mating gears.

**PITCH:** The distance from a point on one thread to a corresponding point on the next thread.

**PLAN VIEW:** The top view of an object.

**PORT:** An internal or external terminus of a passage in a component.

**POSITIONAL TOLERANCING:** The permitted variation of a feature from the exact or true position indicated on the drawing.

**PROCESS SPECIFICATION:** A description of the exact procedures, materials and equipment to be used in performing a particular operation such as a milling operation or spray painting.

**PUMP:** A device which converts mechanical force and motion into hydraulic fluid power.

**QUENCHING:** Cooling metals rapidly by immersing them in liquids or gases.

**RAM:** A single-acting cylinder with a single diameter plunger rather than a piston and rod. The plunger in a ram-type cylinder.

**REAMING:** To finish a drilled hole to a close tolerance.

**RECIPROCATATION:** A straight line, back-and-forth motion or oscillation.

**REFERENCE DIMENSION:** Used only for information purposes and does not govern production or inspection operations.

**REGARDLESS OF FEATURE SIZE (RFS):** The condition where tolerance of position or form must be met irrespective of where the feature lies within its size tolerance.

**RELEASE NOTICE:** The authorization in-

dicating the drawing has been cleared for use in production.

**RELIEF VALVE:** Pressure operated valve which bypasses pump delivery to the reservoir, limiting system pressure to a predetermined maximum value.

**RESERVOIR:** A container for storage of liquid in a fluid power system.

**RESISTANCE WELDING:** The process of welding metals by using the resistance of the metals to the flow of electricity to produce the heat for fusion of the metals.

**RESTRICTION:** A reduced cross-sectional area in a line or passage which produces a pressure drop.

**ROTARY ACTUATOR:** A device for converting hydraulic energy into rotary motion - a hydraulic motor.

**SANDBLAST:** The process of removing surface scale from metal by blowing a grit material against it at very high air pressure.

**SECTION:** A cross-sectional view at a specified point of a part or assembly.

**SENSOR:** Devices which convert physical conditions into information which can be understood by the control system.

**SEQUENCE:**

1. The order of a series of operations or movements.
2. To divert flow to accomplish a subsequent operation or movement.

**SERRATIONS:** Condition of a surface or edge having notches or sharp teeth.

**SERVO MECHANISM:** A mechanism subjected to the action of a controlling device which will operate as if it were directly actuated by the controlling device, but capable of supplying power output many times that of the controlling device, this power being derived from an external and independent source.

**SHIM:** A piece of thin metal used between mating parts to adjust their fit.

**SOLENOID:** A coil of wire carrying an electric current possessing the characteristics of a magnet.

## Glossary of Terms

**SPECIFICATION:** A detailed description of a part or material giving all information not shown on the graphic part of the blueprint such as quality, size, quantity and manufacturer's name.

**SPLINE:** A raised area on a shaft (external) designed to fit into a recessed area of a mating part.

**SPOT FACE:** A machined circular spot on the surface of a part to provide a flat bearing surface for a screw, bolt, nut, washer or rivet head.

**SPOT WELD:** A resistance type weld that joins pieces of metal by welding separate spots rather than a continuous weld.

**STRESS RELIEVING:** To heat a metal part to a suitable temperature and hold that temperature for a determined time then cooled gradually in air. This treatment reduces the internal stresses induced by casting, quenching, machining, cold working or welding.

**SUMP:** A reservoir.

**SUPERSEDENCE:** The replacing of one part by another. A part that has been replaced is said to be superseded.

**SURFACE TEXTURE:** The lay, roughness, waviness and flaws of a surface.

**TABULAR DIMENSION:** A type of rectangular datum dimensioning in which dimensions from mutually perpendicular datum planes are listed in a table on the drawing instead of on pictorial portion.

**TANGENT:** A line drawn to the surface of an arc or circle so that it contacts the arc or circle at only one point.

**TAP:** A rotating tool used to produce internal threads by hand or machine.

**TEMPERING:** Creating ductility and toughness in metal by heat treatment process.

**TEMPLATE:** A pattern or guide.

**TENSILE STRENGTH:** The maximum load (pull) a piece can support without breakage or failure.

**TOLERANCE:** The total amount of variation permitted from the design size of a part.

**TORQUE:** The rotational or twisting force in a turning shaft.

**TRANSDUCER (or feedback transducer):** An element which measures the results at the load and sends a signal back to the amplifier.

**TRUE POSITION:** The basic or theoretically exact position of a feature.

**TUMBLING:** The process of removing rough edges from parts by placing them in a rotating drum that contains abrasive stones, liquid and a detergent.

**TYPICAL (TYP):** This term, when associated with any dimension or feature, means the dimension or feature applies to the locations that appear to be identical in size and configuration.

**VERNIER SCALE:** A small moveable scale attached to a larger fixed scale, for obtaining fractional subdivisions of the fixed scale.

**WORKING DRAWING:** A set of drawings which provide details for the production of each part and information for the correct assembly of the finished product.

# Standard Tables and Symbols

## Decimal and Metric Equivalents

INCHES			INCHES		
FRACTIONS	DECIMALS	MILLI-METERS	FRACTIONS	DECIMALS	MILLI-METERS
	.00394	.1	$\frac{15}{32}$	.46875	11.9063
	.00787	.2	$\frac{31}{64}$	.47244	12.00
	.01181	.3		.484375	12.3031
$\frac{1}{64}$	.015625	.3969	$\frac{1}{2}$	.5000	12.70
	.01575	.4		.51181	13.00
	.01969	.5	$\frac{13}{32}$	.515625	13.0969
	.02362	.6	$\frac{23}{64}$	.53125	13.4938
	.02756	.7	$\frac{35}{64}$	.546875	13.8907
$\frac{1}{32}$	.03125	.7938		.55118	14.00
	.0315	.8	$\frac{9}{16}$	.5625	14.2875
	.03543	.9	$\frac{37}{64}$	.578125	14.6844
	.03937	1.00		.59055	15.00
$\frac{3}{64}$	.046875	1.1906	$\frac{19}{32}$	.59375	15.0813
$\frac{5}{64}$	.0625	1.5875	$\frac{39}{64}$	.609375	15.4782
$\frac{3}{32}$	.078125	1.9844		.625	15.875
$\frac{7}{64}$	.09375	2.3813	$\frac{41}{64}$	.62992	16.00
	.109375	2.7781	$\frac{21}{32}$	.640625	16.2719
$\frac{1}{8}$	.11811	3.00	$\frac{43}{64}$	.65625	16.6688
	.125	3.175	$\frac{47}{64}$	.66929	17.00
$\frac{5}{32}$	.140625	3.5719	$\frac{11}{16}$	.671875	17.0657
$\frac{11}{64}$	.15625	3.9688		.6875	17.4625
$\frac{3}{16}$	.15748	4.00	$\frac{23}{32}$	.703125	17.8594
	.171875	4.3656	$\frac{45}{64}$	.70866	18.00
	.1875	4.7625	$\frac{47}{64}$	.71875	18.2563
$\frac{13}{64}$	.19685	5.00		.734375	18.6532
$\frac{7}{32}$	.203125	5.1594	$\frac{3}{4}$	.74803	19.00
$\frac{15}{64}$	.21875	5.5563		.7500	19.05
$\frac{1}{4}$	.234375	5.9531	$\frac{25}{32}$	.765625	19.4469
	.23622	6.00	$\frac{51}{64}$	.78125	19.8438
	.2500	6.35		.7874	20.00
$\frac{9}{32}$	.265625	6.7469	$\frac{13}{16}$	.796875	20.2407
$\frac{19}{64}$	.27559	7.00		.8125	20.6375
$\frac{5}{16}$	.28125	7.1438	$\frac{27}{32}$	.82677	21.00
	.296875	7.5406		.828125	21.0344
$\frac{11}{16}$	.3125	7.9375	$\frac{53}{64}$	.84375	21.4313
	.31496	8.00	$\frac{55}{64}$	.859375	21.8282
$\frac{23}{64}$	.328125	8.3344		.86614	22.00
$\frac{27}{64}$	.34375	8.7313	$\frac{7}{8}$	.875	22.225
	.35433	9.00		.890625	22.6219
$\frac{3}{8}$	.359375	9.1261	$\frac{29}{32}$	.90551	23.00
$\frac{25}{64}$	.375	9.525	$\frac{59}{64}$	.90625	23.0188
$\frac{13}{32}$	.390625	9.9219	$\frac{15}{16}$	.921875	23.4157
	.3937	10.00		.9375	23.8125
$\frac{27}{64}$	.40625	10.3188	$\frac{31}{32}$	.94406	24.00
$\frac{7}{16}$	.421875	10.7156		.953125	24.2094
	.43307	11.00	$\frac{61}{64}$	.96875	24.6063
	.4375	11.1125	$\frac{63}{64}$	.98425	25.00
$\frac{29}{64}$	.453125	11.5094		.98475	25.0032
			$1$	1.0000	25.4001



## CRITERIA FOR PLACING HANDICAPPED STUDENTS IN REGULAR VOCATIONAL COURSES

Adapted from an Informational Brochure  
Developed by Dr. Claire Szoke  
for the Springfield Public Schools

A physical or mental handicap does not automatically mean that the student will be unable to function in a regular vocational course without special assistance. The ideal goal of vocational adjustment for the handicapped is participation in an occupation in which the mental or physical disability does not constitute a handicap. Thus, a student confined to a wheelchair might be classified as vocationally handicapped in a welding course but would be a "regular" student in bookkeeping. Social maturity and previous vocational skill preparation are also important.

Determination of the probable degree of vocational handicap is the first step in the placement process. The following criteria will be used to determine whether a student has the interest and ability to succeed in a regular vocational course:

- \* The student's behavior (as measured by judgements of teachers and counselors) is not a threat to either his own safety or that of others.
- \* Student expresses interest in course content.
- \* Recommendations of former and current teachers indicate probable success.
- \* Results of specially selected vocational aptitude and interest tests are positive. A number of such tests have been developed for poor readers. These include:

Brainard Occupational Preference Inventory (Psychological Corporation)--note: reading level is 6.4  
Picture Interest Inventory (McGraw-Hill)  
Bennett Hand Tool Dexterity Test (Psychological Corporation)  
Purdue Pegboard (Science Research Associates)  
Crawford Small Parts Dexterity Test (Psychological Corporation)  
Nonreading Aptitude Test Battery (revised version of the General Aptitude Test Battery; source local Illinois State Employment Service Office)

If physically and mentally handicapped students are to be successfully integrated into regular vocational courses, a careful matching of the student and an appropriate learning environment is essential. The following supportive services are ones that can feasibly be implemented in most public schools:

## Materials

- \* Extensive use of audio visual aids: charts, films, slides, tapes, records, video tapes, overhead transparencies
- \* Written version of taped materials (hearing impaired)
- \* Taped versions of written instructional materials

Mentally retarded or slow learners, e.g., students reading two or more grades below grade level:

Retarded students who are very poor readers may have up to a sixth grade comprehension level if the material is in oral rather than written form. Sixth grade comprehension level is the level of many popular magazines, newspapers and television shows.

### Visually impaired

Volunteer service agencies tape textbooks free of charge for the visually impaired -- they cannot do this overnight, however, but must have the text in advance.

- \* Taped versions of written tests and/or tests administered orally to the individual student (mentally retarded, slow learners, visually impaired)
- \* Large print versions of instructional material (visually impaired)
- \* Glossary -- at easy reading level -- of those vocabulary terms essential for the mastery of a particular course. Such a glossary should be used by students both in the vocational class and in their special needs English class. This reinforcement concept is especially valuable for the mentally retarded.

## Resources

- \* Student note-takers (classmate makes carbon copy of his class "lecture" notes for hearing impaired student)
- \* Student teams (pairing special needs student with one or more non-handicapped classmates). If all the students in a class frequently work in pairs or small groups then the handicapped/disadvantaged student will not feel "singled out" for special assistance

- \* Individualized tutoring (out-of-class assistance by special education staff and/or special tutor, e.g., students from Sangamon State University; this service could, when needed, include a reader for the visually impaired or a person skilled in sign language to assist the hearing impaired student)
- \* Instructor aide
- \* Team teaching (special education teacher in class to assist regular vocational teacher; this is now being done in at least one Springfield Middle School)

## CLASSROOM PROCEDURES HELPFUL TO THE SPECIAL NEEDS STUDENT

### Mentally retarded or slow learner

- \* Emphasize hands-on experience.
- \* Use media (video tapes, films, filmstrips, overhead transparencies, charts, taped materials) to reinforce basic concepts.
- \* Use a variety of teaching methods -- some students have a short attention span. They will be happier and more successful if given several short tasks during an hour. If they need a lot of "drill" at a certain point, present it in a different way each time.
- \* Use task analysis, e.g., breakdown of a process into its component parts and the mastery of each task before moving on to the next stage.
- \* Allow ample time to complete a task -- some students take longer than others to perform a task. Rushing them will only make them more anxious and thus more likely to make errors.
- \* Emphasize the positive -- comment on what the student does right, rather than only pointing out errors.
- \* Keep required bookwork to a minimum.

### Physically handicapped (orthopedically, hearing, visually impaired)

- \* Orientation: A small group orientation session should be held for the more seriously physically handicapped students prior to the first class. This orientation should be conducted jointly by the vocational teacher and a special education staff member. If possible, such orientation periods should be scheduled at a time when class is not in session. Such an orientation session should include:
  - \* Information regarding special equipment and resources available
  - \* Tour of the classroom laboratory to acquaint student with location of equipment and supplies (this is essential for the visually impaired)

- \* Opportunity for hands-on trial of basic equipment -- this will enable both the student and teacher to determine what adjustments might need to be made.

A separate but similar orientation session should be held for mentally retarded students.

#### Hearing impaired

- \* Teacher and deaf student should cooperatively develop some simple signs.
- \* Be careful in using words with multiple meanings when talking to lip-reading hearing impaired students.
- \* Speak distinctly and slowly, use simple sentences, and look directly at lip-reading hearing impaired students.
- \* Emphasize demonstrations rather than verbal explanations.

#### Visually impaired

- \* Orderly workshop and individualized instruction regarding the use of each piece of equipment are absolutely essential.
- \* Give the visually impaired student ample time for accumulating finger knowledge -- teacher must aid student in moving fingers for gathering information.

### SUGGESTIONS FOR EQUIPMENT MODIFICATION

#### Hearing impaired

- \* A red light installed next to the switch indicating when the machine is in operation
- \* Bells connected to a light that turns on when the bell rings; applicable on typewriters, class bells, timers, fire alarms, and emergency stop procedures

#### Visually impaired

- \* Control dials and switches that are easily accessible; special control dials with actual rather than visual markings; for this one can use brailled tape or raised marks (e.g., dots of Elmer's glue)
- \* Auditory rather than visual warning signals
- \* Guard plates (where feasible) on power equipment
- \* Specially designed measuring tools, e.g., audible multimeter, audible electronic level, brailled ruler -- see Aids and Appliances 18th ed., 1973, American Foundation for the Blind.

#### Orthopedically impaired

- \* Work tables which can be adjusted to various heights

- \* Semi-stationary equipment should be put on variable height bases.
- \* Sinks and water controls should be accessible to students in wheelchairs.
- \* Guard plates (where feasible) on power equipment; machine switches on power equipment may need to be moved for easier accessibility.
- \* Extra large handles on hand tools for easy use by students with weak hands

The following minor adptions which are desirable for orthopedically impaired home economics students are representative of quick, low-cost modifications which might be made or purchased for handicapped students in other vocational classes:

- \* Cutting board mounted on suction cups so that students with only one hand or with minimal strength would not have to be concerned with holding the board steady; peeling screw to hold vegetables to be peeled
- \* Electric scissors for students with minimal motor control
- \* Grocer's hook for reaching small items without the student's getting out of wheelchair
- \* Electric mixer with a level control instead of the dial-type speed control (also useful for the visually impaired)
- \* Place a lightweight sewing machine on a tray fitted over the arms of a wheelchair.

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